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EMS Credibility and the German Dominance Hypothesis

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Tutkimuksen tavoitteet

Tutkimuksen tavoitteena oli yhdistää kaksi laajalti tutkittua aihetta: Euroopan valuuttajärjestelmän (EMS) uskottavuus sekä Saksan "hallitsevuus olettamus" (German Dominance Hypothesis), jonka mukaan Saksa harjoittaa itsenäistä rahapolitiikkaa, jota muut jäsenmaat ovat pakotettuja seuraamaan valuuttakurssien ollessa kiinteät. Haluttiin selvittää millaisia vaikutuksia valuuttakurssipolitiikan heikolla uskottavuudella on korkojen määräytymiseen valuuttajärjestelmässä, eli heikentääkö vai vahvistaako se Saksan määräävää asemaa.

Lähdeaineisto

Tutkimuskohteena empiirisessä osassa olivat Euroopan valuuttajärjestelmän jäsenmaiden kuukausittaiset kotimaiset markkinakorot aikajaksona huhtikuu 1979 - kesäkuu 1997 sekä jaksoina alkaen toukokuussa 1987 sekä elokuussa 1993. Tutkimuksessa huomioitiin Alankomaat, Belgia, Espanja, Irlanti, Italia, Ranska, Saksa, Suomi (toukokuusta 1987 lähtien) ja Tanska. Lisäksi uskottavuutta tutkittaessa käytettiin dollari spotkursseja sekä ECU keskuskursseja, joista laskettiin valuuttakurssit suhteessa Saksan markkaan. Suurin osa aineistosta saatiin Elinkeinoelämän Tutkimuslaitoksen (ETLA) tietokannasta. Muina lähteinä olivat IMF Financial Statistics, European Economy Annual Economic Report sekä Suomen Pankin Rahoitusmarkkinat Tilastokatsaus.

Tutkimusmenetelmä

Valuuttakurssien uskottavuutta tutkittiin Svenssonin (1991) yksinkertaisimmaksi nimeämällä menetelmällä rakentamalla kotimaisen koron ympärille tuottoväli. Tämän testin avulla korkoihin tehtiin uskottavuuskorjaus ja näillä korjatuilla koroilla saatuja tuloksia verrattiin alkuperäisten korkojen tuloksiin Saksan hallitsevuus olettamusta testattaessa. Analyysin kohteena olivat korkojen yhteisintegroituvuus sekä Granger kausaalisuus. Yhteisintegroituvuutta testattaessa käytettiin sekä Engle-Grangerin että Johansenin menetelmiä.

Tutkimustulokset

Heikoin uskottavuus löytyi pienimmistä jäsenmaista, Belgiasta, Irlannista ja Tanskasta. Ranska kärsi ajoittaisista uskottavuusongelmista, kun taas Espanjaa ja Italiaa suojasi leveämpi valuuttakurssin vaihteluväli. Alankomaiden valuuttakurssipolitiikka oli uskottavaa. Tulokset koko tutkimusajalta osoittavat, että Saksalla on merkittävä asema valuuttajärjestelmän korkojen määräytymisessä. Tämä vaikutus näkyy voimakkaampana uskottavuuskorjatuissa koroissa, joten voidaan olettaa, että Saksa vaikuttaa korkojen fundamentaaleihin heikon uskottavuuden ohjatessa markkinakorkoja. Myöhemmällä ajanjaksolla, toukokuu 1987 - kesäkuu 1997, valuuttajärjestelmästä löytyi kaksi korkoryhmittymää: Saksan ympärillä olevassa ryhmässä ovat Alankomaat sekä Suomi, kun taas Ranskan ympärille ovat asettuneet Espanja ja Italia. Täten voidaan tulkita, että Saksan harjoittamalla rahapolitiikalla on merkittävä asema Euroopassa, mutta tämä vaikutus peittyy muiden maiden puutteelliseen uskottavuuteen.

Avainsanat

Saksan "hallitsevuus olettamus", uskottavuus, yhteisintegroituvuus, Granger kausaalisuus

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1 INTRODUCTION

Many claim that the European Monetary System (EMS) is really a larger Deutschmark area. The EMS was originally intended as a symmetric arrangement, where the countries would jointly decide about the monetary policy for the EMS as a whole. However, there is growing consensus that Germany sets its monetary policy independently from the other member countries, who in turn are forced to follow due to the fixity of the exchange rates. This view has also been recognized in the European Union (EU). The Commission of the European Communities describes the rule for monetary policy coordination in the EMS as an asymmetric rule in which the center country sets its money supply target and the others peg their exchange rates to that of the center by adopting a domestic credit target (1990, 182). Much research has been conducted on the subject, for example Mastropasqua et al. (1988) find that although Germany did intervene in the foreign exchange market to support the other currencies, these interventions were sterilized in the domestic market and intramarginal interventions were left for the other members.

German dominance has also been considered as something desired by the other members. Giavazzi and Pagano (1988) view the EMS as a disciplinary device for the inflation-prone countries in Europe to borrow Bundesbank credibility by pegging their currencies to the German mark. Thus, by joining the system the countries convince the markets of their commitment to reduce inflation, which is seen as an outcome of the interaction between what the authorities want to achieve and what the markets expect the authorities will do. Hence, the weaker currency members achieve lower inflation at lower costs in unemployment. This line of argumentation also gained support from the Commission of the European Communities (1990, 183): ”the exchange rate constraint represented a suitable option for the other Exchange Rate Mechanism (ERM) members, whose disinflationary credibility was initially less strong.”

The German dominance hypothesis has been challenged in several studies. For instance Fratianni and von Hagen (1990) as well as De Grauwe (1991) recognize the German monetary policy independence, but assert that it does not dominate the others. Another opposing view has been presented by Weber (1991), who considers the EMS as a bipolar arrangement, where the hard currency option is offered by the Bundesbank, while the Banque de France supplies a soft option for the weaker currencies, i.e. the countries in the soft currency block have pegged their currencies to the French franc and have thus shared France's credibility in lowering inflation.

Since the significance of credibility on the alleged asymmetry of the EMS has not been researched, this paper attempts to combine these two issues by examining the effect of credibility on the German standing in the EMS. Poor credibility can cause turbulence in the system together with high interest rates. Therefore, to see the true movements of interest rates, the data is cleaned of poor credibility using the simplest test of Svensson (1991). This credibility adjusted data is then employed to examine the German dominance hypothesis and the results are compared with those achieved using the original interest rates. To investigate the convergence of interest rates implied by German dominance, i.e. whether the EMS interest rates move together, co-integration procedures are used. The causal relations within the EMS - how the monetary policy of one EMS country affects that of another - are revealed with the help of Granger causality tests. The principal findings indicate that while the non-credible EMS interest rates moved together and followed each other, the credibility adjusted interest rates seem to have followed the interest rates of the strong economies of Germany and the Netherlands. After 1987 the results lend support to Weber's theory of a bipolar EMS, where a group of countries is centered around Germany and another around France.

The study is organized as follows: a brief introduction of the EMS is provided in chapter two with the theories that lie behind the credibility view of the EMS as well as the German dominance hypothesis in chapter three. Chapter four presents the studies conducted on both subjects and summarizes the major findings and trends in research. In chapter five the tests from De Grauwe (1991) are performed for the period January 1985 - June 1996 to discover whether the outcome of the tests changed after certain events: tighter parities rule of 1987 or the abolition of capital controls in 1990 and how the hypothesis was affected by the EMS crises in 1992 and 1993. Chapter six comprises a credibility adjusted test on the German dominance hypothesis. First Svensson's simplest test is employed to remove poor credibility from the interest rate data. After a description of stationary and non-stationary time series and the presentation of the results, the focus is on the concept of co-integration and the testing procedures used. Next, the findings are presented. Finally, Granger causality tests are conducted on the interest rate data with a summary of results closing the chapter. Only conclusions remain for the eighth chapter.

2 THE WORKING OF THE EMS

The European Monetary System was established in March 1979 as a reaction to the large exchange rate volatility of the European Economic Community (EEC) currencies during the 1970s. The objective was to create a zone of monetary stability in Europe that would facilitate trade and help the conduct of the Common Agricultural Policy (CAP). The EMS was preceded by the European currency snake, which was founded in 1972 after the collapse of the Bretton Woods gold standard. The three aspects of the EMS are the European Currency Unit (ECU), which is a monetary unit based on a basket of all EEC currencies, the Exchange Rate Mechanism (ERM) and credit facilities. The currencies in ERM are allowed to float around the bilateral central rates within certain margins and there is a possibility of realignments, i.e. devaluation or revaluation of the target rate that is based on a common decision by the members. An important feature for the functioning of the system have been intervention rules. When the fluctuation margins of the bilateral rate are reached both countries equally intervene to preserve the rate. This is supported by the Very Short Term Financing Facility (VSTF), where the central banks of strong currencies have an obligation to lend without limits their own currency to the central banks of the weak currencies to defend the existing bilateral margins. The meaning of intervention rules has diminished after the widening of the fluctuation bands in 1993.

While all of the European Union members belong to the EMS, only a group of them belongs to the ERM, which has made ERM the more important feature of the system. In the beginning the members were the currencies of Belgium and Luxembourg, Denmark, France, Germany, Ireland, Italy and the Netherlands. The fluctuation band was set at ±2.25 per cent around the central rate, except for Italy, who enjoyed a wider band of ±6 per cent until in 1990 it came to use the narrower band. Also the newcomers in the system, Spain (1989), the UK (1990) and Portugal (1992), used the wider fluctuation band. Following the 1993 currency crisis the fluctuation bands were widened to ±15 per cent.

Informally, the EMS also aimed for internal monetary stability by pursuing an anti-inflationary policy. In the early years realignments were frequent, due to loss of competitiveness caused by severe differences in the members' inflation rates as well as current account problems. The 1987 Basle-Nyborg Agreement achieved a tighter EMS, where no realignments occurred until 1992. In

1990 the remaining capital controls were abolished, which together with the German unification, recession in Europe and some help from speculators, may have helped to trigger the EMS currency crises in 1992 and 1993. In autumn 1992 the British pound and the Italian lira were forced to leave the system and to prevent additional "drop-outs" the fluctuation margins were widened to ±15 per cent in August 1993. Further tensions in the EMS did not appear until in the end of 1994. This turbulence was initiated by the Mexican peso crisis combined with a weak US dollar and it led to a devaluation of the Spanish peseta and the Portuguese escudo in March 1995. Since then no realignments have taken place.

Austria became an ERM member simultaneously with the country's EU membership in January 1995 and in November 1996 Italy rejoined the system following Finland's entrance in October of the same year. Hence, there are only three EMS members that do not participate in the ERM: Greece, Great Britain and Sweden.[1]

3 THEORETICAL FRAMEWORK

Both the credibility approach of the EMS and the German dominance hypothesis have been studied from several perspectives. This chapter provides both concepts with the theories that lie behind them. In the first section the credibility approach is discussed. After explaining the credibility argument with the help of the Barro-Gordon model, the two contrasting views of the credibility approach - the disciplinary approach and the shock absorber view - are presented. The second section tackles the German dominance hypothesis beginning with the interest rate parity condition and proceeding to the n - 1 problem.

3.1 Credibility approach

An exchange rate policy could be defined credible, when the foreign exchange markets believe that the exchange rate remains at the level announced by the authorities. A requirement for a credible exchange rate commitment is the convergence of the economies. Due to the asymmetric nature of the EMS, where the center country, Germany, has the most averse attitude towards inflation, this is

[1] This chapter is based on Artis and Healey (1995), De Grauwe (1993, 98 - 103) and Mattila (1997).

often interpreted as convergence to the German level of inflation. This has led to the credibility view of the EMS, which presents the EMS as a disciplinary device that has provided a credible framework for disinflation. Lower inflation has thus been achieved with reduced costs in terms of unemployment and lower growth. Inflation is viewed as a credibility problem, i.e. the result from interaction between the goals of the monetary authorities and market expectations.

The credibility argument is based on three assumptions: (i) only surprise inflation affects output and therefore employment; (ii) the public has rational expectations, hence inflation can not come as a surprise on average; and (iii) the government values price stability and high employment (Gros and Thygesen 1992, 126). Essentially, the policy of no inflation is best in the long-run, but the authorities have an incentive to deviate from it in the short-run. This is the Barro-Gordon (1983) model that considers a discretionary regime, where the monetary authority can create inflation surprises by printing more money. These inflation surprises may have some benefits, but they can not rise systematically in equilibrium, as the people understand the policy maker's incentives and set their expectations accordingly. Consequently, the equilibrium rate of inflation will be higher than otherwise. Hence, enforced commitments for monetary behavior eliminate the option of surprise inflation.[2]

The two opposing arguments of the credibility approach are the disciplinary and the shock absorber views. While the credibility argument suggests that the EMS has helped the member countries to disinflate, the disciplinary approach proposes that the EMS has raised the costs of inflation. Realignments maintain the purchasing power parity (PPP) and each country can thus choose the preferred inflation rate. The disciplinary view claims that real appreciation is not compensated for in realignments and therefore the economy loses competitiveness until the domestic inflation rate is reduced. The markets are aware of this loss, which facilitates the central bank's policy of disinflation. (Ranki 1996, 32.)

In contrast to the credibility and disciplinary approaches is the shock absorber (also called instrumentalist and competitiveness) view of the EMS, that states as the purpose of the EMS the ability of its members to better absorb the shocks coming from the rest of the world by distributing their impact among the participating countries. Most importantly, national monetary policy always

[2] Based on Barro and Gordon (1983a, 589; 1983b, 101).

has spill-over effects on other countries. These external effects make a coordination of monetary policy desirable, but an explicit coordination might be difficult to achieve. In the EMS pegging the exchange rate is the form of coordination. The instrumentalist approach evaluates the EMS based on the same criteria as the optimum currency area theory that evaluates the costs and benefits of a monetary union. The criteria are principally symmetric shocks and importance of trade within the union. To the extent that these conditions are fulfilled, the EMS is a useful substitute for more complicated forms of coordination. The shock absorber view does not require symmetry. In fact, the other countries would perhaps benefit from an asymmetric EMS, i.e. pegging their currencies to the Deutschmark, where the Bundesbank would attempt to stabilize the German economy against shocks coming from the dollar area. (Gros and Thygesen 1992, 134 - 135.)

3.2 German Dominance Hypothesis

The German dominance hypothesis asserts that Germany is the center country in the EMS, which sets its monetary policy independently of what happens in the monetary system, while the other member countries are forced to follow due to the exchange rate constraint. All fixed exchange rate systems have to resolve a problem of asymmetry. To see this the theory of fixed exchange rate systems could be begun with the interest rate parity, which states:

$$r_F = r_G + f_p \tag{3.1}$$

where r_F and r_G are the interest rates in two countries F and G (for example France and Germany) and f_p is the forward premium, i.e. the expected rate of depreciation of the currency of country F (here the French franc) relative to the currency of country G (here the Deutschmark), which is calculated as:

$$f_p = (f - e) / e \tag{3.2}$$

where f is the forward rate and e the spot rate as (FF/DM). The condition states that interest rates are equalized across countries taking into account any expected exchange rate changes. For example, in case of an appreciation of the Deutschmark, the French interest rates must exceed the German interest rates to compensate holders of assets in France for the expected loss. With credibly fixed exchange rates ($f_p = 0$) this means that the interest rates in the two countries can not differ. Since interest rates are determined by the monetary policies conducted, the result is that independent decisions about the money supply are not possible for both.

This leads to the n - 1 problem. Given the n - 1 different exchange rates in a system of n countries, one monetary authority is allowed to set its monetary policy freely, while the other n - 1 authorities must follow to maintain the exchange rate.[3] There are two solutions to this problem. In the symmetric model, which was the arrangement for the EMS, the monetary policy is decided jointly. Symmetry in the EMS is promoted with the use of the ECU as an indicator of divergence and with the symmetrical rules of intervention in the foreign exchange market. When the system is asymmetric one country becomes the leader, and the others are then forced to respond to maintain the interest rate parity condition. According to Burda and Wyplosz there are two ways in which a leader in the asymmetric system can be chosen (1993, 416). Within the first method, the most influential country takes the monetary policy freedom, while in the second method leadership is unanimously given to the most reliable central bank.

4 EARLIER RESEARCH

Both the credibility argument as well as the German dominance hypothesis have been researched in great amount since the end of the 1980s. Several authors have addressed both issues, e.g. Giavazzi and Giovannini (1989) as well as De Grauwe (1991; 1993). Here the first section discusses the studies on EMS credibility, while analysis of the German dominance hypothesis is summarized in the following section.

4.1 Credibility

The literature measuring the credibility of the exchange rate policy is all in all fairly young - almost all research on the subject is from the 1990s. The challenge in measurement comes out especially with target zones, since the target zone regime can be deceiving in a number of ways: the central rate can be altered (devaluation or revaluation) and the bands can be widened or completely

[3] Another way to look at the n - 1 problem is that n - 1 exchange rates can be set independently, but not n.

removed (flexible exchange rates). The expectations of the exchange rate changes within the band do not sign lack of credibility, like changes of the regime. Two major lines of research could be recognized. While the first researches examined the ability of the EMS to reduce exchange rate and interest rate volatility, the later analysis employed the testing procedures for target zone credibility created by Svensson in 1991. Next, the different studies are described in detail, which is followed by a short summary.

4.1.1 Survey of Previous Studies

One of the first studies that assessed the issue of credibility in the EMS was from **Artis and Taylor** (1988), who aimed to show if the EMS had induced a greater degree of stability of nominal or real interest rates. They tested for shifts in volatility and predictability of the members' exchange rates, in addition to so called volatility transfers, i.e. whether the possible reductions in exchange rate volatility have increased interest rate volatility. Another issue was the importance of capital controls in maintaining the ERM. The data were monthly bilateral US dollar exchange rates and onshore as well as offshore interest rates for Belgium, Denmark, France, Germany, Italy and the Netherlands besides non-EMS members the US, the UK, Japan and Canada in the period from January 1973 to December 1986. They used non-parametric tests for volatility shifts, which do not require actual estimation of the distributional parameters. The results showed reduced intra-ERM exchange rate volatility and increased volatility in US dollar rates after 1979. These results were confirmed with testing for a shift in conditional variance. The tests also showed some evidence of a reduction in the volatility of interest rates for ERM members. Capital controls have played at least some part in helping the system to function. Artis and Taylor attributed the reduced volatility to the enhanced credibility of the exchange rate policies of these countries, but added that the methods of achieving this have not been approached (1988, 202). In 1993 Artis and Taylor presented a revised version of this work, where the exchange rate data was extended until October 1990 and offshore interest rates stated from the period January 1975 to February 1993. The earlier results gained support: intra-ERM exchange rate volatility - especially bilateral-DM rates - fell, while the volatility of non-ERM currencies remained the same or increased. Hence, the ERM has achieved greater stability over time. The volatility transfer hypothesis was again rejected, which means that the decrease in exchange rate volatility has not led to a rise in interest rate volatility. Artis and Taylor argue that the turbulence in the EMS in the beginning of the 1990s is not inconsistent with the short-run, stabilizing influence of the ERM that is documented here (1993, 22).

Giavazzi and Pagano (1988) investigate the argument of the EMS as a disciplinary device for inflation-prone countries in Europe to help them pursue more restrictive monetary policies. They consider the large credibility gains that EMS membership brings to the policy-makers in these countries, because it not only attaches an extra penalty to inflation (in terms of lost competitiveness), but also makes the public aware that the policy-maker is faced with such penalty (1988, 1055). The central issue is, whether the EMS is a welfare-improving arrangement from the viewpoint of the monetary authority in these countries, not whether it is an effective disciplinary device. Only if the gains are greater than the losses the authorities will be willing to commit and thus enhance their credibility. Their model is based on one country that produces two goods - domestic and export - where the domestic price is a mark-up over wages and the firms in the export market are price-takers. There is a non-cooperative game between the authorities and the worker union, where the outcome affects the profits of the export sector. The results show a problem: EMS regime is unsustainable in the long-run, the countries will eventually have to drop out. The real exchange rate is assumed to fluctuate below the PPP, i.e. it is set back at PPP at each realignment, from where it falls until the next realignment. This shifts domestic demand towards foreign goods, which, with no capital mobility, leads to the foreign exchange reserves to be gradually depleted. Eventually a country will have to leave the system. There are two solutions: fluctuation of the real exchange rate around the PPP rather than below it or temporary membership. Fluctuation of the real exchange rate around the PPP is at odds with the EMS experience so far: the countries with above average inflation have never succeeded in securing realignments large enough as to bring their real exchange rate above PPP, which according to Giavazzi and Pagano indicates that the system, as currently designed, is not indefinitely sustainable (1988, 1066). Temporary membership is credible, as long as the benefits exceed the costs and the country can afford to stay in the system.

The macroeconomic impact of the EMS is examined by **Giavazzi and Giovannini** (1989) from March 1979 to December 1987. The first issue in the study is the stabilizing effect of a credible fluctuation band on the exchange rate, which is studied with evidence on changes in the stochastic behavior of bilateral nominal exchange rates. The effects the EMS has on real variables are another issue, where the behavior of aggregate relative prices is surveyed. The third issue, behavior of effective real rates, reveals two questions. First, whether an exchange rate union, which attempts to stabilize bilateral rates within itself, can destabilize the multilateral rates of its members by destabilizing the exchange rate relative the rest of the world. Second, whether the EMS can be interpreted as a device for stabilizing the DM effective exchange rate (1989, 45).[4] The results on the first issue lend support to those from Artis and Taylor (1988; 1993): the EMS has decreased the volatility of bilateral DM rates, at least for France, Italy and the Netherlands, which is due to the intervention policies in these countries that aimed at stabilizing the bilateral rates and the proposed credibility of the fluctuation bands. In the second issue the hypothesis that the EMS has contributed to a decrease in volatility of relative prices of German, Italian and French goods finds support. Nominal exchange rate regimes like the EMS, are associated with significant real effects, namely a decrease in the variance of unanticipated relative price changes. To observe the third issue Giavazzi and Giovannini use correlations between effective exchange rates, where one is calculated with weights from the IMF's Multilateral Exchange Rate Model and the other one with EMS partner country weights. The results show that since the beginning of the EMS the other currencies have stayed close to the DM, thus contributing to the stabilization of Germany's global competitiveness, compared with the period during the fall of the Bretton Woods, when the DM appreciated relative to both the US and Europe. This theme is discussed further, when Giavazzi and Giovannini analyze the German dominance hypothesis.

Giavazzi and Spaventa (1990) attempted to explain the "new" EMS of the late 1980s, that was characterized by the following developments: removal of exchange controls, transition to more fixed exchange rates, i.e. no realignments since 1987, the end of converging inflation rates and faster demand growth in high-inflation countries. The question was the effect of financial integration and the commitment to fixed exchange rates on the speed and output cost of inflation. First, they analyzed the effects of financial integration on capital flows and exchange rate expectations. Exchange rate stability and financial integration have stimulated capital flows into countries with high inflation and fast growth of domestic demand, like Italy and Spain. Due to the abolition of capital controls in France and Italy in 1990, the gap between the offshore and domestic interest rates has disappeared: the variability between the two series is almost identical. This has, however, been caused more by the reduction in the volatility of the offshore rates than increase in

[4] Effective rates are geometric averages of bilateral rates, where the weights measure a country's competitiveness relative to its trading partners by taking into account changes in the relative price of output in any two countries (Giavazzi and Giovannini 1989, 55 - 56).

the volatility of the domestic rates, which can be accredited to the stabilization of exchange rate expectations (1990, 72 - 73). Next, they analyzed the effect of the regime shift on inflation and the output cost of disinflation, in addition to the adjustment process that followed the decision of the authorities to fix the nominal exchange rate. Financing the current account deficits, which have incurred in the process of achieving the new steady state, happens either through private capital flows or a fall in official reserves depending on the exchange rate expectations. Here it can be seen that the greater credibility and financial integration, the less the cumulative inflation will be during the process of disinflation and the lower the price index in the end. Giavazzi and Spaventa conclude that credibility and financial integration are important assets, although in the short-run they tend to cause difficulties (1990, 83).

A considerable contribution to the analysis of the target zone credibility has been given by **Svensson** (1991), whose work in the beginning of the 1990s has been numerous. The method named as the simplest test measures the credibility of the exchange rate policy in the system of exchange rate bands with the domestic interest rate. The interest rate needs to fall inside of a rate-of-return band, which is calculated as the maximum and minimum domestic currency return on a foreign investment. The method assumes no arbitrage and sufficient capital mobility. Under the assumption of uncovered interest rate parity, credibility is tested by whether expected future exchange rates fall within the exchange rate band. Another method that Svensson has contributed to is the drift adjustment method (also called the Bertola - Svensson method), which adjusts interest rate differentials by the estimated expected rate of depreciation within the band. The expected rates of depreciation within the band are usually of about the same magnitude as the interest rate differentials. These tests are used to evaluate the credibility in the EMS for the original six members of the ERM. The first analysis was for the period March 1979 - May 1990. The results showed that the expected rates of depreciation within the band have been found sizable for the short maturity examined. For sufficiently long maturities the interest rate differential itself is an adequate measure of the expected size of devaluation, and no adjustment of the interest rate differential is necessary. In a later study Svensson (1993) estimates devaluation expectations for the same six ERM currencies until April 1992. He finds that devaluation expectations against the DM are lower in 1992 than in the beginning of the ERM, which means that the exchange rates are more credible. Yet, positive expected rates of devaluation relative to the Deutschmark are found for Danish crone, Italian lire and Irish pound for both the 3- and 12-month horizons and for French franc for the 12-

month horizon. Only for the Dutch guilder and Belgian franc zero expected rates of devaluation are found. Hence, the EMS crisis which followed shortly after the publication of this analysis could be forecast here. Another finding is that interest rate differentials are less volatile than exchange rate expectations, which indicates that central banks use exchange rate movements inside the band to smooth interest rates.

A new interpretation of the EMS is provided by **Weber** (1991). He finds three arguments in favor of a positive answer to the question "has the EMS helped member countries to disinflate during the 1980s?" In addition to the credibility and disciplinary arguments Weber offers a third view: the theory of a bipolar EMS, where a hard currency option is supplied by the German Bundesbank and a soft currency option is offered by the Banque de France (1991, 58 - 59). Before the empirical analysis of counter-inflation reputation as well as of the credibility of money, exchange rate and interest rate targeting, Weber presents the different ways to measure and gain credibility. Credibility is viewed as a measure of the degree to which policy-makers tie their hands on future policies by issuing policy announcements. Two measures of credibility are used. Average credibility (AC) measures the extent to which the public expects policy outcomes to deviate from prior policy announcements. The smaller this deviation, the larger is average credibility. Marginal credibility (MC) focuses on the ability of policy announcements to influence the public's expectations and may be thought of as the weight placed on the announcement when the public forms its expectations. When the counter-inflation reputation of policymakers is examined, the results show that Germany, closely followed by the Netherlands, has the highest anti-inflation reputation prior to and during the EMS period. The smaller EMS economies - Belgium, Denmark and Ireland - have gained anti-inflation reputation during the EMS period, in contrast to France and Italy, who have the lowest counter-inflation reputation and have not increased their reputation during the EMS period (1991, 68). According to Weber there are three ways of gaining credibility: (i) adoption of intermediate monetary targets; (ii) entering a fixed exchange rate system (for a small open economy); and (iii) targeting nominal interest rates. Following, credibility of the different policy announcements is tested. Monetary targets were chosen by Germany, France and Italy in the mid-1970s and have remained part of their practices. Credibility has declined, since the EMS countries have not been very successful in achieving their monetary targets (1991, 69 - 71). Next, Weber compares the credibility of exchange rate targeting under the Bretton Woods system, the European currency snake experiment and the EMS. The results indicate that exchange rate fixity was most credible during the

Bretton Woods and the European currency snake and that the credibility of the exchange rate commitment has declined in the EMS compared with the earlier systems. This could be explained by the wider fluctuation margins and more frequent realignments under the EMS (1991, 74). Based on AC and MC estimates it can be seen that the EMS has not functioned as a DM-zone, but as a bipolar system. While Weber suggests that a de facto monetary union already is in place between Germany and the Netherlands, at least Belgium, Denmark and Ireland have chosen the soft currency option, offered by the French franc. Exchange rate pegging within this block was credible, but the block seems to have dissolved after 1987, when some of the members have adopted the hard currency option. The exchange rate commitment of Banca d'Italia has never been credible, although towards the end of the period, just before the adoption of the reduced fluctuation margins, its pegs towards the former soft currency block have gained credibility. Weber considers interest rate targeting an operational procedure to control the exchange rate, but the co-existence of the hard and soft currency blocks implies that there is no automatic link between interest rate targeting and counter-inflationary policies (1991, 81). The smaller economies have gained short-term credibility, but they lack long-term credibility, which is highest with Germany and the Netherlands. The results indicate that interest rate targeting policies in the EMS have predominantly been oriented towards the stabilization of exchange rates within the band. Weber concludes that the "new" hard EMS provides a favorable starting condition for the Monetary Union.

Loureiro (1992) came to the same conclusion as Weber (1991) in his study of discipline and credibility in the EMS. For the discipline hypothesis to be valid, the following two conditions must be filled: (i) the inflation-prone countries became less tempted to "cheat" after joining the EMS; and (ii) EMS membership is required for a reduction of the temptation to "cheat". The methodology used to answer these questions included all variables in the EMS discipline/credibility thesis, i.e. money supply, exchange rate and output besides inflation, which had been focus in earlier research. The first condition was accurate, while the second one was rejected, as was the hypothesis. Louireiro tested the credibility of the EMS with using Svensson's simplest test for exchange rates, where the forward exchange rate should lie inside the fluctuation band. The test was performed for the Belgian and French francs, the Danish crone, the Irish pound, the Italian lira and the Dutch guilder, out of which all showed lack of credibility, except the guilder. Finally, improvement of credibility over time was examined by means of forward excess returns that were defined as the log difference between the n-month ahead spot rates and the current m-month forward rates. The results here were not significant. The correspondence of Loureiro's findings with those of Weber are further discussed, when his tests on the German dominance hypothesis are presented in the next section.

Realignment expectations were used to measure exchange rate credibility in a study by **Rose and Svensson** (1993) since if policy makers are to be able to manipulate the level of credibility, they must first have a clear view about the determinants of realignment expectations (1993, 1). Special notice was taken on the EMS crisis in September 1992 to see whether macroeconomic divergence was the cause of poor credibility and the currency crisis. Rose and Svensson used two measures for realignment expectations: raw interest differentials and interest differentials adjusted for expected exchange rate drift (the drift-adjustment method), which due to their close relation give the same answer. The data were daily exchange and interest rates for Belgium, Denmark, France, Germany, Ireland, Italy and the Netherlands in the period from March 13th 1979 to the end of October 1992. The results show that the credibility of European exchange rate pegs varies considerably over time, mostly due to reasons that are not explained by macroeconomic variables. Only inflation differentials vis-à-vis Germany affect ERM realignment expectations in a systematic way. The EMS crisis in August 1992 was not anticipated by the markets and signs of poor credibility were not found. Rose and Svensson find two explanations for the fall of the ERM: doubts about European Monetary Union (EMU) or the unwillingness of policy-makers to react to the shock of German unification with a general realignment of the ERM (1993, 27).

De Grauwe (1993) claims that EMS credibility has always been impaired by recessions. His study looks for the causes of the EMS breakdown by examining the political economy of a monetary union and the difficulties that remain. There are two factors that damage credibility. The adjustment problem is initiated by asymmetric economic disturbances. While alternative adjustment methods are often difficult and costly, the credibility of the authorities' promise not to use the exchange rate is often diminished. The liquidity problem (the n - 1 problem) causes policy conflicts on the appropriate monetary policy in the system, which give countries an incentive to devalue or opt out of the agreement. The liquidity problem may also lead to self-fulfilling speculation. According to De Grauwe the EMS crises in 1992 and 1993 were mostly due to the liquidity problem, which originated from two reasons: the German unification and the recession that hit Europe at the same time. Policy conflicts arose. Large financing needs resulted in increasing inflation in Germany, where the authorities then pursued restrictive policies. France and the UK on the other hand demanded looser monetary policy to combat the recession. The exchange rate constraint forced them to choose between following Germany or leaving the system, which was noticed by the speculators. This caused the withdrawal of the UK from the system in 1992 and the crisis with the French franc in 1993. The successive speculation against Italy and Spain in 1992 had its origins in the adjustment problem, caused by the persistent inflation differentials between these countries and Germany. (De Grauwe 1993, 124 and 1994, 152 - 153.) This analysis of the n - 1 problem suggests that unemployment may be an important factor affecting EMS credibility, i.e. rising unemployment causes a policy conflict, where countries that give a larger weight to unemployment than inflation demand an expansionary monetary policy. De Grauwe relates the simplest method based on interest differentials with average EMS unemployment rates. There is strong correlation between the credibility measures and the average unemployment rates. In 1990s, whereas inflation convergence remained unchanged, EMS credibility declined with rising unemployment. EMS credibility suffered most during recessions, which has overruled the positive effects of increased inflation convergence (1994, 157). De Grauwe sees that the wider fluctuation bands instituted in 1993 make the move towards the EMU technically easier.

The effects of German Monetary Unification (GMU) in July 1990 on EMS credibility were examined in the study of **Ranki** (1996) for the period January 1987 - September 1992, when no realignments occurred. Svensson's credibility measures were again employed. The results revealed that the Belgian, Danish, French, British and Italian Euromarket rates were all above the interest rate band, whereas the Dutch and Spanish rates stayed inside the band.[5] All of the currencies achieved full credibility in early 1990 and the GMU did not affect the stability of the EMS exchange rates, i.e. the credibility of the EMS exchange rates did not worsen after 1990. Hence, the 1992 crisis was not anticipated by the markets based on the expected rates of devaluation. Consequently, Ranki criticizes the simple test with interest rates and expands the method to test the credibility of the EMS exchange rates. This method shows that the interest rate differential does not yield an expected future spot exchange rate, but rather the sum of two factors: the expected future spot exchange rate assuming that the band is credible as well as the product of the probability that it is non-credible - and thus the exchange rate will be devalued - and the expected size of the devaluation (1996, 85). Here the countries could be divided into three groups according to their

[5] It should be noted that Spain had a wider interest rate band due to the wider fluctuation band for the exchange rate.

degree of credibility. The Belgian franc and Dutch guilder exchange rates relative the Deutschmark belong to the most credible group with the smallest devaluation expectations. The Danish, French and Spanish DM rates belong to the intermediate group, whereas the poorest credibility throughout the period is found with Italy and Great Britain. Ranki concludes that in general the period is characterized through increased convergence and diminishing devaluation expectations (1996, 111).

4.1.2 Summary

In 1988 Giavazzi and Pagano introduced their theory of the EMS as a disciplinary device, where the member countries by tying their hands would gain central bank credibility and discipline from German anti-inflationary policies. There are two arguments against this borrowing Bundesbank credibility hypothesis: first, there were frequent realignments until 1987, which is not a sign of a credible commitment to a fixed exchange rate and second, a constitutional reform of the central bank, i.e. an independent central bank, would achieve the same result (Burda and Wyplosz 1993, 417).

The first research on the credibility of the EMS has examined the stability of exchange and interest rates. The volatility of both has decreased during the functioning of the system and there have been no volatility shifts from exchange rates to interest rates. Recent contributions have analyzed the issue in the framework of target zone models. Here especially the work of Svensson has been prominent. Both the simplest method and the drift adjustment method that he has helped to create have been used since to evaluate the credibility of target zones. The results vary. It could be concluded that even though the volatility of the exchange rates decreased in the EMS, it was not as credible as its predecessors, but its record may be improving.

4.2 German Dominance Hypothesis

Several studies have been conducted on the alleged asymmetry of the EMS. Table 4.1 on page 22 summarizes the empirical research on the German dominance hypothesis.[6] The different indicators for the degree of asymmetry are, according to Gros and Thygesen (1992, 137):

[6] Another survey on the German dominance hypothesis can be found in Ranki (1997).

(i) the sensitivity of the system to fluctuations in the US dollar/DM rate, e.g. Artus et al. (1991)

(ii) the distribution of intervention strategy, e.g. Giavazzi and Giovannini (1989)

(iii) the degree to which central banks sterilize the effects of interventions on their domestic monetary aggregates, e.g. Mastropasqua et al. (1988)

(iv) patterns in money supply correlation, eg. Fratianni and von Hagen (1990)

(v) interest rate linkages, eg. Karfakis and Moschos (1990).

The first category considers tensions in the US dollar/DM market that lead to pressure in the EMS as indicators of the special position the Deutschmark has in the system. Some evidence is found that movements in the US dollar/DM rate precede realignments in the EMS. The most formal evidence of German dominance is found in the second category, where it can be seen that Germany's intervention policy is indeed quite different from that of the others. Since intervention can be sterilized in the domestic market, intervention data do not have direct influence. Thus, the third category examines the differences in the extent that central banks sterilize the impact of foreign exchange interventions on domestic liquidity.

The last two categories search an answer to the n - 1 problem, i.e. who determines the monetary policy in the system. As instruments of monetary policy either monetary base or interest rates are chosen. A common method used in both cases are co-integration and Granger causality tests.[7] Another approach concerning interest rates argues that if Germany dominates the EMS, portfolio shifts should not have any effect on German interest rates, since the Bundesbank would be able to offset them. Following, the studies are discussed in detail with a summary in the end.

[7] If a set of variables is co-integrated then, although each series may be individually non-stationary, there must exist at least one linear combination which is stationary. This linear combination can be thought of as a long-run relationship towards which there is a continual mutual tendency of the variables to adjust - in other words , the series tend to move together over time. (MacDonald and Taylor 1991, 554) Granger causality tests examine in the simplest form, whether lagged values of X contribute significantly to the explanation of Y_t, once lagged values of Y have been incorporated; if they do, then X is said to Granger-cause Y (Darnell 1994, 42).

Table 4.1 Empirical Studies on the German Dominance Hypothesis

Study (Year)	Method & Variables	Years	Result*
Giovannini (1988)	Interest rates and realignments		A
Mastropasqua et al. (1988)	1) Interventions and sterilization 2) VAR models on the monetary base and bilateral exchange rates	M3:1979 - M6:1987	A
Giavazzi & Giovannini (1989)	1) Interventions 2) Interest rates and realignments	M1:1983 - M4:1986	A
Honohan & McNelis (1989)	Realignments and exchange rate predictability		A
Fratianni & von Hagen (1990)	1) VAR models on money market rates and changes in the monetary base 2) Realignments	M3:1979 - M4:1988	S
Karfakis & Moschos (1990)	Co-integration (Engle-Granger) and Granger causality of short-term domestic interest rates	M4:1979 - M11: 1988	A
Artus et al. (1991)	1) Granger causality of short-term interest rates 2) Maximum likelihood tests on transmission of US policy	M1:1980 - M6:1988	A
De Grauwe (1991)	1) Interest rates and realignments 2) Interdependence of short-term offshore and domestic interest rates	M3:1979 - M3:1988	B/S
Kirchgässner & Wolters (1991)	Co-integration (Engle-Granger) and Granger causality of short-term Euromarket rates	M1:1980 - M12:1988	A
Kutan (1991)	VAR models and Sims' block-exogeneity tests on the money growth rates	M3:1979 - M1:1989	S
MacDonald & Taylor (1991)	Co-integration (Johansen) and Granger causality of nominal and real exchange rates and nominal money supplies	M3:1979 - M12:1988	A
Beyer & Schmidt (1992)	Co-integration (Engle-Granger) of short-term domestic interest rates	M3:1983 - M12:1991	A
Biltoft & Boersch (1992)	Granger causality of daily domestic interest rates	M1:1983 - M12:1991	A
Herz & Röger (1992)	Estimation of a stochastic, neoclassical version of the Mundell-Fleming model	Q1:1980 - Q4:1988	A
Koedijk & Kool (1992)	A modified version of the principal components analysis for interest and inflation differentials	M3:1979 - M9:1989	B
Loureiro (1992)	VAR models on domestic credit using the variance decomposition technique	M3:1979 - M6:1988	B
Kirchgässner & Wolters (1993)	Co-integration (Johansen) of short-term Euromarket interest rates	M1:1980 - M12:1988	A
Hafer & Kutan (1994)	Co-integration (Johansen), Granger causality and Sims' block-exogeneity tests on short-term interest rates and the monetary base	M3:1979 - M12:1990	S
Kirchgässner & Wolters (1995)	Co-integration (Johansen) and Granger causality of domestic short-term interest rates	M1:1974 - M11:1994	A/S
García-Herrero & Thornton (1996)	Co-integration (Johansen) and Granger causality of short-term interest rates	M4:1979 - M8:1992	A/S
Ranki (1997)	Central bank reaction functions on short-term interest rates	M1:1980 - M6:1996	A/S
Siklos & Wohar (1997)	Co-integration (Johansen) of short-term Euro-deposits and inflation rates	M1:1973 - M7:1995	A/S

* S = Symmetry, A = Asymmetry and B = Bipolar EMS

4.2.1 Survey of Previous Studies

Interest rate behavior in relation to parity realignments was studied by **Giovannini** (1988). When in a symmetric regime international portfolio shifts are reflected in both countries' rates, in an asymmetric regime the central country's rate remains unaffected. Only the rates of other countries are altered by international portfolio disturbances. Giovannini used a simple test of the asymmetry hypothesis, based on the observation of countries' interest rates in correspondence with observable international portfolio shifts, i.e. parity realignments. Large swings in the offshore interest rates of the other EMS members can be seen, as well as the strikingly stable pattern in the German domestic and offshore rates. An objective function for the central banks was constructed and the hypothesis that, in the central country the deviations of the domestic target from its desired value are white-noise errors, was tested. The results rejected the notion of white noise significance for other countries, but not for Germany. Hence, his analysis confirms the German dominance hypothesis.[8]

Mastropasqua, Micossi and Rinaldi (1988) analyzed the interventions, sterilization and monetary policy in the EMS countries for the time period 1979 - 1987 to observe their role in maintaining ERM cohesion. They first examined the intervention rules and intervention patterns in Germany, Belgium, France and Italy and discussed the different ways the sample countries have combined interventions, exchange rate and interest rate flexibility in their policy approaches. Another topic of discussion were the various institutional aspects of monetary management and coordination. Then, econometric estimates of individual countries' sterilization policies and certain aspects of monetary policy interaction in the ERM were presented. The findings differed from the symmetrical intentions of the system. The central banks intervened in substantial amounts already in the beginning, with the US dollar being the currency mostly used. The last years of the observed period saw a doubling of the intervention volumes, while the share of the interventions in EMS currencies exceeded that of the dollar interventions. This could be attributed to the growing amount of intramarginal interventions that were carried out in EMS currencies. The Bundesbank made substantial interventions at the margin in EMS currencies, while making no intramarginal interventions. It mostly intervened at the dollar market in not ERM-related operations. The other central banks carried out most of their interventions during periods of strong DM, which meant most of the time dollar weakness. Mastropasqua et al. state that intervention patterns should be

[8] Based on Ranki (1997, 9).

examined in the context of countries' stances regarding both the position of their currency in the band and the flexibility of interest rates on domestic markets (1988, 263). They estimated central bank reaction functions relating monetary base creation through domestic channels to changes in the foreign component of the monetary base and to variables representing the domestic objectives of monetary policy, inflation and growth. A clear difference emerged in sterilization behavior. Germany sterilized on average between 60 and 80 per cent of interventions, while Italy and France did so only to the extent of 30 and 40 per cent, respectively, of their foreign exchange interventions. When estimating VAR models (vector autoregressions) relating Germany's monetary base to that of the others and the corresponding bilateral exchange rate, it could be seen that the growth rate of the monetary base in Belgium, France and Italy is significantly influenced by German base money and by the exchange rate vis-à-vis the Deutschmark. Mastropasqua et al. concluded that Germany has played the *n*th country role of supplying the system with a monetary standard and increasingly with the intervention and reserve currency (1988, 282). The other countries have followed, using the ERM exchange constraint as their compass.

Intervention data was also examined by **Giavazzi and Giovannini** (1989) for the period from January 1983 to April 1986 to see whether intervention rules guarantee the symmetry of the system. The countries included were Germany, Belgium, France, Italy and the Netherlands. Their results confirmed those of Mastropasqua et al. Germany only intervened when the margins were reached, while intramarginal intervention, which was largest in volume, was carried out by the other members. Due to a wider fluctuation band Italy never intervened at the margin. Bundesbank was responsible for large dollar sales, especially during times of dollar appreciation. Giavazzi and Giovannini recognize that in the presence of domestic sterilization, intervention rules are useless in determining, whether an exchange rate union is symmetric or not (1989, 67). This is shown by a minimal "accounting" model of international money market equilibrium with two countries. All the stress of the model is on the accounting relationships between foreign exchange reserves, domestic credit, foreign exchange intervention and sterilization, thus the term "accounting". The system is asymmetric, when the responses of the interest rates to an international portfolio shock differ. The monetary authorities have different objectives: the center country attempts to control its own money supply, while the other countries aim for control of the foreign exchange reserves. This analysis was empirically tested: EMS interest rates were examined in the periods preceding a realignment. The results showed asymmetric responses of interest rates. Capital controls in France managed to insulate the domestic rate, while the French offshore and both Italian offshore and domestic rates moved considerably in the months before the realignment. The German rates were hardly affected by expectations of changes in the DM price of the Italian lira or the French franc, which suggests that the n - 1 problem is de facto solved asymmetrically in Europe. Giavazzi and Giovannini attempted to build a reaction function for the central bank that would consider the implications of both assumptions about central bank behavior, targeting domestic or international variables, but the data rejected the model. They concluded that the foreign exchange market intervention rules can be made completely ineffective by domestic monetary policies (1989, 82). Therefore, symmetric foreign exchange intervention rules do not solve the n - 1 problem at all.

The effect of EMS realignments on the ability to forecast the exchange rate was studied by **Honohan and McNelis** (1989). While no evidence was found to show the DM/USD rate to be affected, realignments have influenced the ability to forecast the US dollar exchange rates of the other EMS currencies considerably. Their conclusion was that the Deutschmark functions as the dominant EMS currency.[9]

Fratianni and von Hagen (1990) present a theoretical and empirical analysis of the German Dominance Hypothesis (GDH) that credits German leadership for reduction and convergence of inflation rates in the EMS since 1979 (1990, 93). Four conditions defining GDH are stated (von Hagen and Fratianni 1990, 364):

1) world insularity, i.e. the other EMS countries can be influenced by the world only through its impact on German policy;
2) EMS insularity, i.e. the policies of the EMS members do not react to each other, except for the German policy;
3) rejection of independence of German policy, i.e. the monetary policy in a member country must depend critically on the German policy and
4) German policy independence, i.e. the Bundesbank itself can not be influenced by the policies of the others).

[9] Based on Ranki (1997, 11).

The tests from Fratianni and von Hagen concentrate on monetary policy actions instead of inflation rates, the outcomes of these actions. They build a system of central bank reaction functions using VAR models to analyze changes in the monetary policy games in the EMS, in an attempt to illustrate the manner in which a central bank responds to the world market, EMS and German variables. The EMS countries are Belgium, Denmark, France, Ireland, Italy and the Netherlands. For short-term monetary policy actions the monthly changes in money market rates are chosen as dependent variables and for the medium term the quarterly percentage changes in the monetary base. The GDH is rejected. However, some evidence is found that would support the weak form of German dominance, in which short run but not long run deviations from the Bundesbank rule are allowed, in contrast to the strong form that does not allow any short-run deviation from the path prescribed by Bundesbank policy (1990, 97). Fratianni and von Hagen conclude that the Bundesbank has an independent monetary policy, but it does not dominate the EMS. The two safety-valves to retain monetary policy independence in the other countries are capital controls and realignments (1990, 100 and 111). Another test by Fratianni and von Hagen concentrates on realignments. They distinguish between the size and timing of realignments, because if devaluation times were known, speculation could force earlier devaluation, but if the timing was uncertain speculation need not rise (1990, 102). To emphasize this point exchange rate anticipations in the system are examined as a function of anticipations regarding the discrete event of realignment and those of exchange rate changes, given a realignment occurs or not. The data support the notion of realignments working as a safety-valve; the size and timing of them were often anticipated. The flexible view of the EMS is confirmed and on a general level Fratianni and von Hagen conclude that the convergence of inflation rates in Europe resulted more from similar central bank attitudes towards inflation than from the EMS (1990, 111).

A time series analysis of interest rates linkages within the EMS is made by **Karfakis and Moschos** (1990). They employ co-integration techniques and Granger causality tests to investigate whether there exist long-run co-movements between German and other EMS members' rates and whether German interest rate changes convey information about future movements of other EMS interest rates (1990, 389). The empirical results suggest that all interest rate series are integrated of order one - I(1), i.e. they contain a unit root.[10] To test for co-integration the two-step approach from Engle

[10] The concepts of stationary and non-stationary time series are discussed further in section 6.2.

and Granger is used.[11] The hypothesis of no co-integration is rejected indicating that there exists an error correction representation, which means that there is Granger causality in at least one direction. VAR models in first differences are used to examine whether the German interest rates are indicators of the future EMS interest rates. The results suggest that the Belgian, French, Italian and Dutch, but not Irish, interest rate changes can be predicted using information on the past evolution of German interest rate changes, while the German interest rates seem to be Granger-exogenous with respect to other EMS members' rates. Instantaneous causality is found with Belgium, Italy and the Netherlands, whereas capital controls have isolated France. These results support the hypothesis of Germany's anchor role in the EMS. Karfakis and Moschos also note that the results are similar across countries with substantial differences in the degree of capital mobility.

Besides the asymmetry in the EMS **Artus, Avouyi-Dovi, Bleuze and Lecointe** (1991) also investigate the transmission of interest rate changes from the United States to Europe. If transmission from the US is strong combined with the asymmetry in the EMS, countries like France have almost no degree of freedom, while both the short- and long-term interest rates result from foreign influences and policies. The purpose of the study is to evaluate to what extent such loss of monetary independence has actually occurred in the EMS countries or whether the countries have preserved certain autonomy in their monetary policies. Artus et al. estimate a model for the determination of the short-term and long-term interest rates in France and Germany and of the Deutschmark/dollar exchange rate from January 1980 to June 1988. First a standard efficiency test is used to test whether the expectations about the DM/USD exchange rate are rational. The rationality hypothesis is weakly rejected with both perfect and imperfect capital mobility. The result implies that it would have been possible to "beat the market". Granger causality tests are performed on the interest rates and their possible explanatory variables using a cutoff date in May 1983. The asymmetry is confirmed: the French short term rate depends mostly on the German short-term rate, on the FF/DM exchange rate and on the current balance, while the short-term rate in Germany is determined by the short-term rate in the US and the USD/DM rate. Next, Artus et al. use the maximum likelihood method to estimate their model that consists of reaction functions on the French and German short-term rates, the term structure between short- and long-term interest rates

[11] In the first step, the parameters of the co-integrating vector are estimated by running the static regression in the levels of the variables and in the second step, these are used in the error-correction form (Banerjee et al. 1993, 157). This procedure is explained in more detail in section 6.3.

and the DM/USD exchange rate. The results from the causality tests for the short-term are confirmed and it is shown that US rates are transmitted to French ones, indirectly, via German rates. The dependency of long-term rates on short-term rates is weak in both France and Germany. The Deutschmark/dollar exchange rate is reasonably well explained by the German/US short-term interest rate differential. Even though the asymmetrical functioning is confirmed, the overall impact of changes in the US interest rates on European rates is limited, which means that the international transmission mechanism has not removed all degrees of freedom of monetary policy in Europe (1991, 1382 - 1383).

De Grauwe (1991) tests the hypothesis of the asymmetric EMS by examining the behavior of interest rates from two different aspects. The first part studies the reaction of interest rates to speculative disturbances in the EMS which are represented by changes in the forward premium. The second part illustrates interdependence of interest rates with causality tests. The basis for the first issue is the interest rate parity. De Grauwe examines whether a change in the forward premium of an EMS currency relative to Deutschmark results in an interest rate change in only one country or in both countries. In an asymmetric system with German dominance, the effects of an expected devaluation are absorbed by the weak currency country, leaving the German interest rate unaffected. This is accomplished with the use of sterilization policies in Germany to offset the monetary effects of a speculative disturbance. When the system functions symmetrically, the money supplies and interest rates in both countries change. Capital controls are brought into the equation. They form a wedge that allows both money markets to be insulated from disturbances (1991, 209). When the German sterilization policies and capital controls in the weak currency country work perfectly, the system is symmetric, even though Germany sets monetary policy independently. Like Giavazzi and Giovannini De Grauwe finds that the domestic interest rates - in contrast to the offshore interest rates - in Belgium, France and Italy remained relatively unaffected by speculative disturbances concerning the Deutschmark. This means that the countries were able to insulate their domestic market from the disturbances. For Netherlands, which has not used capital controls the result is different. The analysis suggests that neither the Dutch nor the German markets were completely unaffected by the shocks in the guilder/Deutschmark rate. Therefore, the German dominance hypothesis is rejected. This lends support to the theory of a bipolar EMS presented by Weber in 1991. A soft currency block is formed around France with Belgium and Italy, in contrast to the hard currency alternative supplied by the Bundesbank, where a de facto monetary union between

Germany and the Netherlands already exists. In the second part De Grauwe studies the interdependence of interest rates, because the ability to insulate the domestic market from speculative disturbances, can not be equated to conduct of independent monetary policy (1991, 220). These Granger causality tests examine the extent to which the interest rate of one EMS country is affected by another one, given the influence of the US. The results show that the German interest rates appeared to influence the interest rates of Belgium, the Netherlands and France, but that the German interest rates also depended on the Belgian and French interest rates. De Grauwe concludes that Germany has not dominated the monetary policies in the EMS and the system has indeed worked in a rather symmetrical way (1991, 224).

Kirchgässner and Wolters (1991) analyzed the bilateral dependencies between the development of the three-month Euromarket interest rates and the DM Euromarket rate to see whether these relationships are symmetric or German dominated. They distinguished their work from that done by Fratianni and von Hagen (1990) in two points: tests were conducted also for countries outside the EMS and more importantly they examined the non-stationarity of the interest rates as well as the possibility that there exist long-term equilibrium relationships between them, i.e. that they are co-integrated. Following Fratianni and von Hagen (1990) Kirchgässner and Wolters offered the subsequent DM-dominance hypothesis: (i) there exist Granger-causal relationships from the DM to the other currencies; (ii) there exist no Granger-causal relationships from the other currencies to the DM; and (iii) all influences on the other currencies in the EMS come through the DM, that is, there are no Granger-causal relationships from non-EMS to EMS members and between the EMS members, except for Germany (1991, 506). In this paper only (i) and (ii) were relevant. First, the authors tested for Granger causality and then for co-integration using the Engle-Granger methodology, after which they estimated the error correction model. Based on causal relationships within the system, the EMS could be interpreted as a DM-zone: there was only one unique one way causal relationship from Germany to France and Italy, but simultaneous causality between Germany and the Netherlands. The non-EMS members, Great Britain, Switzerland and the US, were not dominated by German monetary policy. The co-integration tests revealed the validity of the uncovered interest rate parity. The Euromarket rates moved together, but with this test nothing could be said of the direction of the influences. For this an error correction model was used. There existed a feedback relation between Germany and the US, while German long-term Euromarket rates seemed to dominate both the members' and the European non-members' rates, so the DM in fact does exert the anchor function in the EMS. Kirchgässner and Wolters contemplated, how the results would change if domestic rates were used instead of Euromarket ones. This was done by Karfakis and Moschos (1990) for approximately the same period and the results confirm those of Kirchgässner and Wolters.

A further analysis of the German dominance is offered by **Kutan** (1991) with the hypothesis that the EMS has increased the co-movements of money demand between countries in the system, i.e. have the countries given up their monetary policy independence and allowed Germany to determine their money supply growth rates. This hypothesis bases on the assumption that interest rates are pegged, in which case the money stock is endogenous. If German dominance holds, the other member countries are expected to adjust their monetary policies to the changes in the German money supply growth rate. Hence, in equilibrium when money supply equals money demand, individual demand functions should move closely with German money demand. The German dominance hypothesis follows Fratianni and von Hagen: (i) German money growth can affect the EMS (rest of the countries) money growth; (ii) US money growth can not affect the EMS money growth once the reaction of the German money to the US money growth is allowed; and (iii) no other individual EMS country can affect the EMS money growth, including that of Germany (1991, 289). Kutan builds a dynamic system of equations explaining money growth rates as a function of the EMS countries' money growth rates, the world money growth rate, exchange rate objectives, inflation rates and real income growth rates (1991, 285). Each system of dynamic equations are estimated using the concept of block-exogeneity tests of Sims in a frame work that allows for simultaneous correlation of the equation residuals.[12] Kutan employs monthly data from March 1979 to January 1989 for all countries in the EMS, except Belgium. The results are more consistent with the shock absorber interpretation of the EMS than the credibility interpretation. Money demand disturbances were strongly correlated in the EMS, which implies that the EMS serves as a shock absorber and is an instrument to reduce the variability of inflation, which, in turn, implies a greater scope for and benefit from monetary policy coordination in the EMS (1991, 292).

The convergence of the monetary policies within the EMS is subject of the study from **MacDonald and Taylor** (1991). They measure the extent of real and nominal exchange rate and monetary

[12] Block-exogeneity tests impose restrictions on the system as a whole, i.e. whether all EMS countries can react to one country's money simultaneously. The null hypothesis is that the lags of one set of variables do not enter the equations in a system for the remaining variables.

policy convergence in the long-run and compare these results between the EMS members and non-members. The methodology consists of co-integration and Granger causality tests. The data are bilateral US dollar exchange rates for the EMS (France, Germany and Italy) and non-EMS (Canada, Japan and the UK) currencies and the nominal money supplies in all of these countries, including the US. They first test for unit roots and find that all series are I(1). To test for co-integration the multivariate technique from Johansen is used.[13] A unique co-integrating vector is found for the EMS currencies, while the hypothesis of co-integration for the non-EMS countries must be rejected. This is interpreted as long-run convergence of monetary policies within the EMS, which raises the question of how this convergence has been achieved (1991, 556). To determine whether the convergence is of a symmetric origin or whether it derives from the German leadership hypothesis Granger causality tests are run on the money supply rates, since the existence of a unique co-integrating vector implies that Granger causality must run in at least one direction. The results show Granger causality from the German money supply to that of the other two. This supports the view that foreign exchange intervention to support intra-EMS parities is predominantly undertaken by other members, while intervention is sterilized more by Germany than the others (1991, 557). MacDonald and Taylor see this as a way the German monetary policy transmits throughout the EMS area.

Beyer and Schmidt (1992) criticize the forward premium based model of De Grauwe and re-perform the tests for the period February 1979 - December 1991 with Belgium, France and Italy. The tendency of De Grauwe's results is confirmed. Next, the statistical properties of the model are tested. The following two conditions are necessary for the reliability of the analysis: first, the statistical assumptions of the model must not be violated and second, the relevant parameters must be stationary. Considering the tests from De Grauwe the data reject both of these hypotheses. The basic model does not bring any adequate representation to explaining the changes in the interest rates, which according to Beyer and Schmidt makes it questionable to draw any conclusions on the workings of the EMS from it (1992, 8). They examine the changes in interest rates between the realignment of March 1983 and end of 1991 based on co-integration and error correction methods. The methodology of Engle and Granger is again employed. With the interpretation of the results, they differentiate between institutional and functional asymmetry. Institutional asymmetry bases

[13] The Johansen method is concerned with identifying the number of co-integrating vectors within a general n-variable VAR model. The method is described with more detail in section 6.3.

itself on institutional frames, where one country sets its official interest rates and the other central banks must follow without delay. A part of the frame are the instruments that are used to defense the domestic monetary markets from speculative disturbances, for example sterilization and capital controls. The asymmetry is functional, when the workings of the system are examined in respect to adjustment processes, that is, as market interest rate influences in other countries. The results indicate that the capital controls in France and Italy were not able to isolate all speculative disturbances, which means that the hypothesis of institutional symmetry must be rejected. While functional symmetry is rejected between Germany and France respectively Italy, it seems that both the German and Belgian interest rates took part in the adjustment process, even though not in equal amounts. Beyer and Schmidt note that before this can be interpreted as functional symmetry, the institutional conditions between Germany and Belgium should be analyzed (1992, 18). Hence, the results show more evidence in favor of asymmetry.

Interest rate causality and asymmetry in the EMS are investigated by **Biltoft and Boersch** (1992) for 1983 - 1991. Their hypothesis assumes that Granger causality runs unidirectional from Germany to the other countries. The difference between previous work on causality is the use of daily instead of monthly interest rate data. Adjustments in the financial markets are rapid, so the changes in the German interest rates are likely to be followed within days. The four elements of the German dominance from Fratianni and von Hagen are also used here: world insularity, EMS insularity, rejection of independence of German policy and German policy independence. Biltoft and Boersch test independence of German policy and German policy independence and present a "reversed" test of world insularity, where the effect from the outside world is taken for granted. The results indicate that in recent years the EMS has worked in an asymmetrical way. Since 1987 the relationship between German and the core countries of the EMS - Belgium, Denmark, France and the Netherlands - and Ireland has been unidirectional. Italy has consistently been isolated from German policy, which can be adhered to capital controls and a wider fluctuation band. Finally, Biltoft and Boersch note that even though the EMS has not worked asymmetrically from the beginning and not for all member countries, it still has functioned asymmetrically in recent years for the core countries (1992, 304).

Herz and Röger (1992) criticize the analysis done by Fratianni and von Hagen (1992, 1419):

> They implicitly assume that only foreign and domestic monetary as well as domestic fiscal policy shocks matter. Other shocks, i.e. goods supply and demand, foreign fiscal policy, are not accounted for. Depending on the relative size of the included and the excluded shocks their estimates and consequently their tests may be biased.

In their test Herz and Röger integrate the real and monetary sectors by using a stochastic, neoclassical version of the Mundell-Fleming model, where the exchange rates in the system are fixed and the block is then floating against the outside. The assumptions in the EMS are price flexibility, wage rigidity and perfect capital mobility. The analysis differentiates between the reserve and non-reserve country. The reserve country either does not intervene or sterilizes its interventions in the foreign exchange market. The monetary growth in the fixed exchange block is determined by the reserve country, who provides the reserves, while the non-reserve country stabilizes the exchange rate through interventions (1992, 1417). The effects of shocks in the two countries differ. The reserve country can isolate itself against all other shocks except domestic supply, monetary policy and the world interest rate shocks. In the non-reserve country all shocks remain effective. When one of the countries proves to be the reserve country, the system is considered asymmetric with that country being the leader. In a symmetric system both central banks intervene with equal amounts. The results of the empirical analysis prove the German dominance hypothesis for at least Denmark, France, Ireland and the Netherlands. Belgium and Italy have conducted successful capital controls and realignment policies, which were still valid during the time of the research, 1980 - 1988. The results also indicate that the French capital controls were not working effectively before they were removed simultaneously with the Italian ones in 1990. The research from Herz and Röger indicates a pronounced dominance of German monetary policy in the EMS.

Dominant interest rate and inflation differentials within the EMS are examined by **Koedijk and Kool** (1992) over the period March 1979 through September 1989. The aim is to see whether they could be attributed to specific countries or groups of countries. The countries included are Belgium, France, Germany, Ireland, Italy, the Netherlands and the UK. The approach from Koedijk and Kool differs from most of the earlier research in two ways. They focus on bilateral interest and inflation differentials between each pair of countries, as opposed to Germany functioning as the sole benchmark country. The other difference is the use of the principal components analysis instead of

VAR models.[14] The principal components technique allows a simultaneous analysis of all bilateral interest and inflation differentials within the EMS as a system. To observe the increased degree of convergence within the EMS, the full sample of evidence is compared with the period from March 1983 to September 1989. Koedijk and Kool achieve similar results as Weber, whose conclusion was that there exist a hard currency block around the Bundesbank and a soft currency block adopting the policies of Banque de France. They find a division between Germany, Netherlands and the United Kingdom on the one hand and Belgium, France and Italy on the other. The results show that the hypothesis of a Deutschmark-zone must be rejected both for the whole period and the sub-period after 1983. While the Netherlands and Germany practically already form a monetary union, there exist a substantial amount of independent interest and inflation movements. These may be due to the timing and implementation of the deflationary policies in the EMS (1992, 938). It is also noted that the variation in inflation differentials has fallen since 1983, while the variation in interest rate differentials has remained constant. This would according to Koedijk and Kool suggest a discrete jump to permanently fixed exchange rates instead of the gradual convergence suggested in the Delors report (1992, 941).

Louireiro's (1992) study assessed German dominance as well as the issues of discipline and credibility viewed in the previous section. To examine the independence of monetary policy he analyzed the sterilization of exchange market operations. The usual way of computing the sterilization coefficients (for example Mastropasqua et al.) was challenged by allowing other variables rather than simply the domestic credit component to be endogenously determined, and by introducing dynamics into the equation. For this the forecast variance decomposition technique was used.[15] The Deutschmark exchange rate did not bind the French or Italian monetary policies, i.e. they were not dependent on Germany. The Netherlands did not use domestic credit as an active monetary policy, meaning that it was more dependent of the exchange rate. Belgium and Denmark were intermediate cases. When the monetary policy dependence/independence was ranked on a scale from 0 to 100 the Netherlands comes out as the most dependent one with a coefficient of 11,3

[14] Principal components technique is a statistical device by which a set of k correlated variables is transferred into a set of k uncorrelated variables: the uncorrelated variables are called the principal components, and each principal component is a linear combination of the original variables. One objective is to examine, whether a small number of components accounts for most variation in original data; if this is the case then the analysis may be reduced to a set of variables smaller than k and dimension of the problem may be correspondingly reduced. (Darnell 1994, 314.)

[15] The variance decomposition technique is based on the moving average representation of the VARs and it measures the contributions of each source of innovations to the variance of the *n*th period ahead forecast error for each endogenous variable.

compared with France on the other end of the list with 64,3. This supports the findings on the credibility issue and is in accordance with the bipolar EMS theory from Weber (1991).

The multivariate co-integration technique developed by Johansen is employed by **Kirchgässner and Wolters** (1993) for a later test of German dominance. The technique was also used by MacDonald and Taylor (1991), but for long-run convergence of exchange rates and money supplies. Kichgässner and Wolters use the same interest rate data set as in their earlier research (1991). The long-run GDH is again formulated after Fratianni and von Hagen, but this time in terms of error correction models; (i) German interest rates are included in the error correction terms of the equations of other member countries; (ii) interest rates of other member countries are not included in the error correction terms of the German equation; (iii) interest rates of third countries in the EMS are not included in the error correction terms of the equations of other EMS member countries; and (iv) interest rates of countries outside the EMS are not included in the error correction terms of the equations of EMS member countries except Germany. For long-run GDH to hold there have to be n - 1 co-integrating relationships between n countries. If there exists only one stochastic trend within the EMS and if this is the one driving German interest rates, then Germany controls the long-run development in the other EMS countries and therefore only (i), (ii) and (iv) are necessary (1993, 774). There is again evidence in favor of asymmetry. The variables are found non-stationary, but co-integrated. The GDH holds despite the violation of EMS insularity in a model for the member countries, since dependence of the other countries on Germany is found and German independence can not be rejected (1993, 776). In the models including the United Kingdom and the US the long-run GDH also holds. A strong feedback relation between Germany and the US is again found. They conclude that Germany has a strong position in Europe, which in the long-run could be viewed as a dominant one. This dominance is not restricted to the EMS.

Co-integration techniques were also employed by **Hafer and Kutan** (1994), who studied the long-run monetary policy convergence and German dominance in the EMS between March 1979 and December 1990. Short-term interest rates and the monetary base were used as measures of monetary policy with the aim to determine the number of shared common stochastic trends among EMS monetary policies and to test whether a complete convergence of policies has been achieved in the EMS (1994, 684 - 685). First, the time-series characteristics of the interest rate and monetary base data for Belgium, France, Germany, Italy and the Netherlands were determined. The results indicate that the level of series are all I(1). Co-integration tests suggested the existence of three or two common stochastic trends with interest rates shared by the countries, whereas only one co-integrating vector was found with the monetary bases, which is a similar finding as that from MacDonald and Taylor (1991), who also examined co-integration of money supplies. Whereas MacDonald and Taylor interpreted this as long-run convergence, Hafer and Kutan emphasize that finding four co-integrating vectors would indicate one stochastic trend and thus complete convergence. This is in accordance with the definition of Kirchgässner and Wolters (1993), where n - 1 co-integrating relations meant complete convergence. The results are interpreted as partial transmission of monetary policies across the EMS countries. Therefore, the complete convergence hypothesis as well as the German dominance hypothesis are rejected in the long-run, in contrast to Kirchgässner and Wolters (1993) who confirmed the hypothesis with a different data set. When causality tests are used to determine the short-run relationships, it can be seen that changes in German interest rates have a statistically important influence on interest rate changes in other countries, with the exception of Italy. The German interest rates are also influenced by the Dutch rates and there is interaction between the non-German countries. The block-exogeneity tests of Sims were used to test whether each country could influence the other EMS countries as a group. The results differed for interest rates and the monetary base. While for all countries, except Belgium, changes in monetary policy (interest rates) influenced the interest rates in the EMS as a group, there is unidirectional causality going from the German monetary base to that of Belgium, France and the Netherlands. The view that short-run German policy changes are transmitted to other countries more through the monetary base than interest rates - as has also been suggested by Fratianni and von Hagen (1990) and Kutan (1991) - is confirmed with these results. An implication of the results from this research is that the credibility provided by the EMS is necessarily not an advantage, since the EMS' success in stabilizing exchange rates is mostly attributable to its asymmetrical functioning with the Bundesbank providing credibility. The "lesson" from Hafer and Kutan is that a fixed exchange rate system will not provide full credibility and does not work well over the long-run (1994, 694).

Kirchgässner and Wolters (1995) present a revised version of their earlier work. The interest rate linkages between the US and Europe are examined before and during the EMS period. This time three-month domestic money market rates are used instead of the Euromarket ones for Belgium, France, Germany, Italy, the Netherlands, Switzerland, the UK and the US. In order to observe whether the EMS has changed the possible German influence on the other monetary policies, they firstly examine the period before the EMS from January 1974 to February 1979 and compare it with two EMS periods, January 1983 - December 1989 and January 1990 - November 1994. During the EMS period, the situations of member countries are compared with those of non-members. The conditions for German dominance from Fratianni and von Hagen (1990) are employed here in terms of Granger causality for interest rates. Using the Johansen technique the hypothesis of no co-integration is rejected. The null hypothesis that German interest rates have no influence on the interest rates of the other European countries, can always be rejected: in the second and third period for both EMS and non-EMS countries. The US interest rates have an impact on interest rates in Europe during the first and second periods. The results from Kirchgässner and Wolters are in line with those from Fratianni and von Hagen. Germany has, especially in the long-run, a strong position in Europe, but this position does not prevent countries outside the EMS from influencing member countries of the EMS. Also, the dominant position of Germany may be in relation to the EMS, but it is not limited to it. Kirchgässner and Wolters conclude that some influence from the US on Europe was found, and especially on Germany, and the strong position the Bundesbank has on interest rate developments in Europe is recognized (1995, 453).

A further study on the interest linkages in the EMS is from **García-Herrero and Thornton** (1996), where they employ data before the EMS crisis in September 1992. The analysis consists of co-integration and Granger causality tests for all countries, who still belonged to the ERM in August 1992. The German dominance is followed after Fratianni and von Hagen in terms of Granger causality. Firstly, García-Herrero and Thornton examine whether there exists long-run comovements between German and other EMS members' interest rates. Secondly, they study whether short-run changes in German interest rates convey information about future movements in other EMS interest rates, and vice versa. Thirdly, the role of US interest rates in EMS interest rate linkages is examined. The German dominance implies: (i) unidirectional Granger causality running from German interest rates to other EMS interest rates; and (ii) that the impact of the rest of the world's monetary policy (represented by developments of US interest rates) on EMS interest rates is dominated by movements in German interest rates (1996, 1). The results show that the interest rate series are co-integrated and therefore causally related. There is unidirectional causality from German interest rates to the rates in Belgium, France, Spain and the UK and bi-directional causality between German interest rates and the rates in Denmark, the Netherlands and Italy, while there is no

Granger causality between the German and Irish rates. The results are credited to integrated financial markets and the discipline of a formal exchange rate mechanism. The hypothesis of a co-integrating relationship between the US and EMS interest rates does not find strong support in the analysis, in addition US interest rate developments do not change the pattern of EMS interest rate linkages markedly in the short run. It is concluded that the inclusion of US interest rates shift the balance of the Granger causality test toward bi-directional causality, which is consistent with the arbitrage activity which is to be expected from efficient capital markets.

The years after the "collapse" of the EMS are included in the study from **Ranki** (1997), who examines the monetary policies in the ERM countries from January 1980 to June 1996. The model bases on a loss function that the central bank has to minimize. There are three elements: (i) interest rate variability, which is a cost from using the policy instrument; (ii) the standard short-term Phillips-curve related trade-off, i.e. both the inflation rate and the output are aimed on the optimal level; and (iii) ERM, where the central bank needs to react during deviations from the target rate. The relative weight of these targets is tested with a VAR equation, where the domestic short-term interest rate is explained with the domestic inflation rate, domestic production, the exchange rate, German short-term interest rate and the US short-term interest rate. The results for the domestic variables show that while the explanation power of the inflation rate rose after the mid-1980s, it fell towards the mid-1990s. Domestic production affects monetary policy only when there is a danger of overheating in the economy. In conclusion, the role of the domestic variables for monetary policy determination has remained the same during the whole period. As for foreign variables, German interest rate is significant only for Belgium and the Netherlands. The deviation of the exchange rate from the central rate is significant in determining monetary policy in the other countries, which means that all countries have attempted to follow German monetary policy at the same time as they have tried to minimize devaluation expectations. This effect has diminished after the widening of the exchange rate bands, which means that the EMS now functions more symmetrically than before.

The latest study on the convergence of interest rates in Europe is from **Siklos and Wohar** (1997). Using co-integration analysis they examine the transmission of economic disturbances in financial markets through interest rates and inflation rates, because understanding their temporal behavior across countries says something about the extent to which countries choose to conduct independent monetary policies (1997, 129). The data are Euro-deposit rates and national inflation rates with maturities from one month to one year for ten countries consisting of the EMS countries, the US, Canada and Japan in the period January 1973 - July 1995. Interest rates and inflation rates are considered separately for two reasons: firstly, there has been interest on comparative performance of inflation combined with the motive of the governments to consider providing more statutory independence to their central banks. Secondly, nominal interest rate movements reflect behavior in financial markets, whereas inflation performance reflects that in the goods markets and equilibrium is not likely to be achieved equally quickly in both markets. Siklos and Wohar define convergence - like for example Hafer and Kutan (1994) - as one common stochastic trend shared by the time series, i.e. if there are n series and n - 1 co-integrating vectors, the series contain a common stochastic trend. After reporting all interest rates and inflation rates as I(1), co-integration tests are conducted. Since one stochastic trend is not necessarily a feature of the whole data sample, the period 1976 - 1982 was first tested and thereafter a year was added at a time until the full sample was reached. The second part of the test considered combinations of the countries based on institutional or geographical realities. Siklos and Wohar find that although there is a co-integrating structure that is inconsistent with convergence among the EMS countries considered, in the second half of the eighties the interest rates did converge and one stochastic trend was found between Germany, the Netherlands and Belgium as well as between Germany, the Netherlands and France. When inflation rates are considered, nine co-integrating vectors are found among the ten countries at the one-month horizon. The conclusion is that the countries considered have attempted to implement independent monetary policies, if interest rates are used as indicators of monetary policy, but not to an extent, which would have produced divergent trends in inflation.

4.2.2 Summary

Many studies have attempted to prove the German dominance hypothesis and the outcomes of these analyses have been as numerous. The results have either confirmed the hypothesis, which means an asymmetric EMS, or rejected it. When the system has been considered symmetric or bipolar. In a bipolar EMS a soft currency block is centered around France, in contrast to the hard currency block of the Deutschmark. The different outcomes could be perhaps attributed to data, time period or the methods used.

Most studies have employed monthly data and one might agree with Biltoft and Boersch, who state that due to the rapidity of the financial markets, changes in German interest rates are likely to be followed within days (1992, 298). Use of daily data has provided support for the German dominance hypothesis, while with monthly or quarterly data all outcomes have been possible.

Interest rates were chosen as the observed variables in most cases, since they are considered to reflect the conduct of monetary policy. The results have differed notably. Whereas the German dominance may have been confirmed with offshore rates, it has in most cases been rejected with domestic ones, which could be accredited to capital controls that were not removed until 1990 in all countries. Foreign exchange intervention data have tended to support the hypothesis of German dominance, while other variables, e.g. the monetary base, have often rejected it.

Almost all research states from the time before the EMS crisis in 1992. Even though this period shows all outcomes, a tendency can be seen that the symmetric EMS of the early years appears to have evolved into an asymmetric or a bipolar one towards the end of the period. While capital controls and the wide use of realignments seem to have helped members maintain monetary policy independence, a convergence of policies can be seen after the Basle-Nyborg agreement in 1987, where the use of realignments was limited. The studies from Ranki (1997) and Siklos and Wohar (1997) show that after the collapse the system seems to have become more symmetric.

Co-integration and Granger causality tests make up for the most part of analysis, where the results tend to be in direction asymmetry. The effects of the changes in the system on the outcome of this methodology are examined in chapter six, where the influence of poor credibility is also accounted for.

5 TESTS FROM DE GRAUWE FOR 1985 - 1996

The tests from De Grauwe are a representative example of the research made on the German dominance hypothesis. The use of interest rate and exchange rate data as well as the simple testing procedures are an advantage, which makes them easily implemented. Thus, they are re-conducted for a more recent time period. The last year included in the analysis from De Grauwe was 1988. Since then several changes have occurred in the EMS. Both of the instruments named as safety-valves by Fratianni and von Hagen (for example 1990, 111) have been abolished. In 1987 the EMS moved to a tighter form by giving up the option of a realignment and in 1990 the remaining capital controls were abolished. The EMS crises in 1992 and 1993 also caused turbulence in the system and eventually led to the widening of the fluctuation bands. The aim here is to determine the effects of these changes for De Grauwe's conclusion of the EMS working in a symmetrical way.

The tests done by De Grauwe for years 1979 - 1988, are performed here with quarterly data from January 1985 until June 1996. All short-term interest rates are money market rates (for the US, the treasury bill rate) and long-term interest rates are government bond rates. The interest rate data was taken from IMF's International Financial Statistics. The forward premium is calculated based on average monthly spot rates and three month forward contracts in the Frankfurt exchange. This data source was the Bundesbank's Statistische Beihefte zu den Monatsberichten der Deutschen Bundesbank and Die Währungen der Welt. The econometrics program used was EViews.

5.1 Interest Rates and Realignments

The countries examined in this section are France, Italy and the Netherlands. First, the model of De Grauwe (1991) based on the forward premium is introduced, after which the data are presented graphically. Then, the empirical findings are discussed. Finally, the results are compared with those achieved by De Grauwe (1991) as well as those achieved by Beyer and Schmidt (1992).

5.1.1 Methodology

Graphically, if the interest rate curve of the other EMS country takes the same shape as the forward premium, which is calculated relative to Deutschmark, one can interpret that the disturbance was absorbed mostly by the other country. This combined with an unaffected German interest rate makes the system asymmetric. For instance, if a shock caused the forward premium FF/DM to increase, then a rising French interest rate would imply an asymmetric system. In a symmetric system the adjustment is taken by both countries, in which case both interest rates move or alternatively, neither of the interest rate curves is affected by the movements of the forward premium.

This visual evidence was tested empirically with a model that explains the quarterly changes in the interest rate of an EMS country (not Germany) with its own past quarterly changes, with the past and present quarterly changes of the US interest rate and by the change in the forward premium of the EMS currency relative to the Deutschmark. For the other EMS country this can be written (De Grauwe 1991, 216):

$$\Delta r_{X,t} = \sum \alpha_{iX} \Delta r_{X,t-i} + \sum \beta_{iX} \Delta r_{US,t-i} + b_X \Delta f_{XG} + u_{Xt} \tag{5.1}$$

and for Germany:

$$\Delta r_{G,t} = \sum \alpha_{iG} \Delta r_{G,t-i} + \sum \beta_{iG} \Delta r_{US,t-i} + \sum c_{Xi} \Delta f_{GX} + u_{Gt}. \tag{5.2}$$

In the equations r_X, r_G and r_{US} are the interest rates of the EMS country, Germany and the US, of which two time lags are used. f_{XG} / f_{GX} are the forward premiums. For example in the case of France, the forward premium would be expressed as FF/DM in equation (5.1) and DM/FF in equation (5.2). The model states that when the forward premium of the French franc relative to Deutschmark increases, the French interest rate will also rise, as measured by the coefficient. When b_X is close to one and the relevant c_X close to zero, the system is asymmetric. Coefficients close to 0,5 imply a symmetric system, where the adjustment is shared between the EMS country and Germany.

Different breakpoints in the time series were also tested to see the effects of the changes in the system, that is whether the results change after for example 1990 in France and Italy. For this a Chow test was used that examines the model's parameters for instability. A probability of the likelihood ratio smaller than 0,05 states that the hypothesis of structural stability can not be accepted with a probability of error smaller than five percent.

5.1.2 Results

The results for the estimation of the equations (5.1) and (5.2) are summarized in table 5.1 for the short-term and in table 5.2 for the long-term. The results appear partially ambiguous. Only three of the coefficients are significant at the five per cent level and several of them achieve values greater than one, thus coefficients that would according to De Grauwe indicate symmetry (both ~ 0,5) or asymmetry (b_X ~ 1 and c_X ~ 0) are not seen here. This might indicate that the model is not very reliable.

Table 5.1 Estimation of Equations (5.1) and (5.2): Short-term

	b_X	c_F	c_I	c_N	R^2	D-W
France	-0,35				0,21	1,93
Italy	21,56*				0,33	2,32
Netherlands	-59,50				0,26	2,09
Germany		-2,71	-0,69	120,27*	0,47	2,16

* significant at the 5% level.

Table 5.2 Estimation of Equations (5.1) and (5.2): Long-term

	b_X	c_F	c_I	c_N	R^2	D-W
France	-0,16				0,63	2,00
Italy	-1,31*				0,44	2,23
Netherlands	-27,49				0,49	1,91
Germany		-2,22	-3,63	52,02	0,47	1,86

* significant at the 5% level.

The long-term French interest rate together with the FF/DM forward premium is presented in Figure 5.1. The system seems to be symmetric before 1987, when the EMS was determined to be a truly fixed exchange rate system. After 1987 the long-term interest rates follow the forward premium. The similarity of the curves is most evident before the EMS crisis in 1992 and 1993, where speculators anticipated that France would withdraw from the system like Great Britain. The solution was widening of the fluctuation margins to 15 per cent in August 1993, after which the curves move more independently.

The system became more asymmetric, when realignments were not possible, but as the exchange rate was allowed to move more freely after 1993, the interest rate started moving more independently. Observation of Herz and Röger that the capital controls in France were not efficient after mid-eighties (1992, 1423), is also proved with this graph: the interest rate that should have been sheltered from outside influences, is affected by the forward premium FF/DM. The short-term French interest rates behaved in the same manner as the long-term ones. The figure of the short-term rate can be found in the appendix (Figure 1).

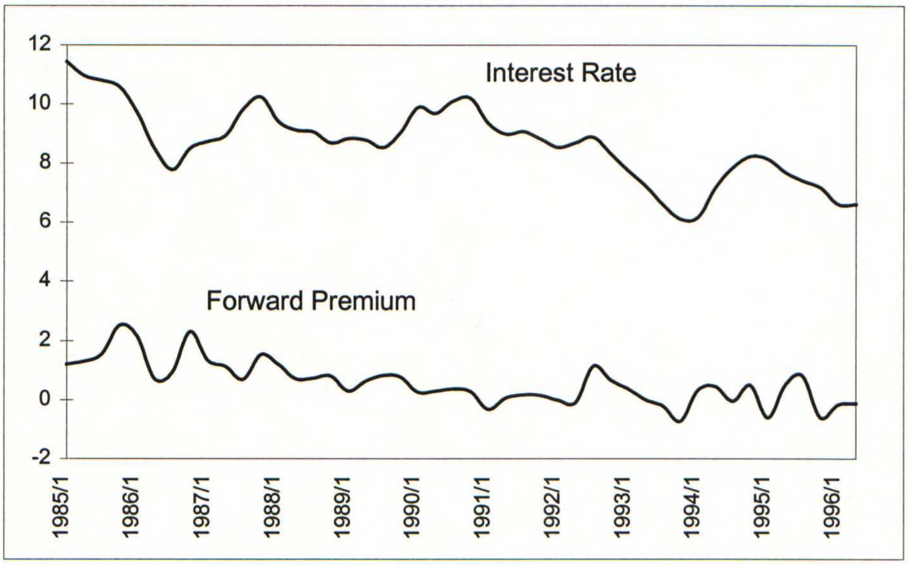

Figure 5.1 French Long-term Interest Rate and the Forward Premium FF/DM

When formally tested the results do not reveal any signs of the forward premium influencing the French interest rates. Under the accepted error probability of 0,05 only the coefficient for the before previous French interest rates in case of the short-term and the present US interest rates in the long-term are significant in determining the French interest rates. The breakpoints were tested in July 1990 and August 1993, but the results did not reveal any breakpoints in the time series. The asymmetry hypothesis can not be confirmed for France.

Italy continuously lost competitiveness after 1987 once it lost the option of a realignment. It was not able to close the inflation gap with Germany, which could perhaps be adhered to the poor credibility of its government. In 1990 Italy abolished capital controls and moved from using the wider 6 per cent fluctuation band to the narrower 2,5 per cent band. After the speculative crisis of September 1992, Italy was forced to leave the system. It rejoined the system on November 25th 1996. These developments can be seen in figure 5.2.

Most of the eighties capital controls and the wider fluctuation band sheltered the interest rate. In the beginning of the nineties the exchange rate stabilized, which allowed Italy to use the narrow band. The narrower band in conjunction with giving up capital controls resulted in the system becoming asymmetric. The speculative crisis of 1992 was completely absorbed by Italy, which then lead to the exit of Italy from ERM. After this most of the shocks appeared in the exchange rate, while interest rates moved less. The same development can be seen in the long-term Italian interest rates, which are featured in the appendix (Figure 2).

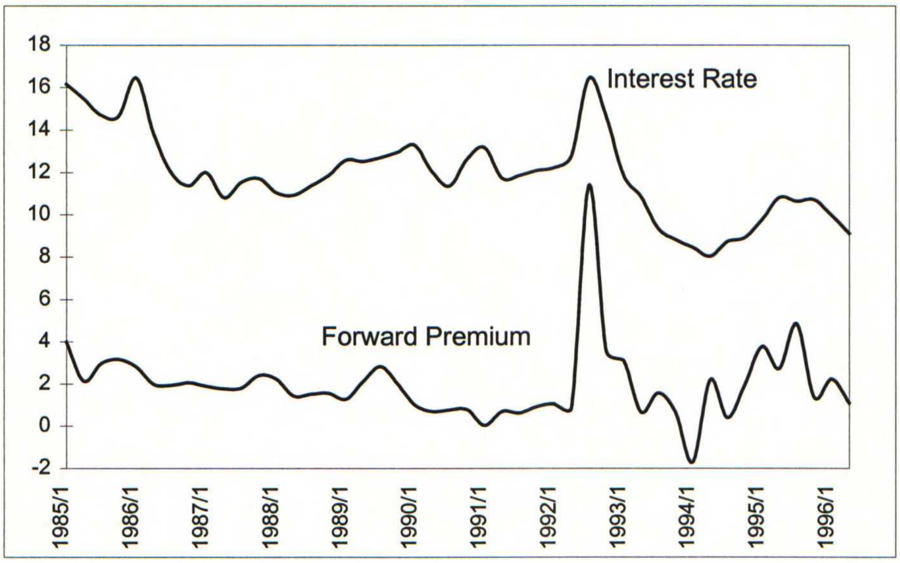

Figure 5.2 Italian Short-term Interest Rate and the Forward Premium ITL/DM

The test results for the Italian interest rates confirm the graphs. The short-term Italian interest rate shows great dependency of the forward premium of Italian lira/Deutschmark at the significant level. The coefficient implies that a one per cent increase in the forward premium leads to a 21,56 per cent increase in the short-term Italian interest rate. This could be interpreted as asymmetry. The long-term rate provides a somewhat controversial result: the forward premium is the sole significant variable in determining the long-term rate, but the coefficient is negative, which means that the forward premium and the interest rate move in opposite directions and the hypothesis is thus rejected. The US long-term rate does not influence the long-term rate in Italy unlike in the other countries. The evidence does not confirm a breakpoint in July 1990, but especially the long-term interest rate provides evidence for the breakpoint of September 1992, when Italy ejected from ERM. With this test it can not be said, whether asymmetry existed before or after the breakpoint.

The Dutch monetary policy has always been closely tied to the German economy. The exchange rate between the Dutch guilder and the Deutschmark has remained relatively stable for years and the Dutch official interest rates closely follow the development of the German ones (Mattila 1997, 24). This is in accordance with Weber's finding that the Netherlands belong to the hard currency block around the Bundesbank and that the two countries in practice already form a monetary union (1991, 78). The figures of the Dutch rates (Figures 4 and 5) are found in the appendix. Asymmetry can be seen with the short-term rates from the start of the period, 1985, until 1988, whereas the long-term rates move parallel with the forward premium after 1992. Between 1988 and 1992 both the short- and long-term rates move opposite of the forward premium.

This visual evidence is confirmed with empirical testing. The previous period Dutch interest rates were significant in determining both the short- and long-term rates. The strongest influence on the long-term rates were, like in France, the present US interest rate. Therefore, German dominance is not proved for the Netherlands.

The German interest rates have moved independently or completely opposite of the forward premiums. The empirical results are to the most part in accordance with this. Only the Deutschmark/guilder forward premium is significant in explaining the changes in the short-term German rate. The coefficient is strongly positive, which means that a one per cent rise in the forward premium causes the interest rate to rise with 120 per cent. This could be explained by the closeness of the Dutch and German economies, where quarterly data are not sufficient to observe the fast changes of the financial markets. The only significant variable with the long-term rate was the present long-term rate in the US.

5.1.3 Discussion

The results achieved here differ from those of De Grauwe (1991) and from Beyer and Schmidt (1992), who also performed this test. According to De Grauwe the offshore rates behave in an asymmetrical manner, but with the domestic rates the changes of the forward premium had no effect on the Belgian, French nor Italian interest rates. There was interaction between the Dutch and German economies. These results led to the conclusions that the EMS has worked in a symmetrical way, which has achieved by the use of sterilization policies in Germany and capital controls in the other countries (De Grauwe 1991, 219). The coefficients received here diverge from those of De Grauwe, among other things by several of them being negative and not between 0 and 1. This could be explained by the differing time period, the use of quarterly instead of monthly data or the claim of Beyer and Schmidt (1992, 8), that De Grauwe's model does not deliver an adequate representation to explaining the interest rate changes in the EMS.

Beyer and Schmidt conducted tests using De Grauwe's model for the time period from February 1979 to December 1991. They received similar results as De Grauwe. The offshore rates confirmed the asymmetry hypothesis, whereas the results with the domestic rates showed that the interest rates moved fairly independently of the forward premium with coefficients for the other countries close to 0,3 or 0,7, which confirm neither the asymmetry (coefficients close to one) nor the symmetry (coefficients close to 0,5) hypothesis. The major criticism of Beyer and Schmidt was that the basic assumptions of the model were violated. The null hypothesis was that the model is linear, normally distributed, not auto-correlated nor heteroscedastic. Beyer and Schmidt rejected the hypothesis, which led to the conclusion that the results from the test could be biased. Another criticism of Beyer and Schmidt considered the stationarity of the variables. They found the variables indeed to be non-stationary, which as well may be a source of bias in the results. Therefore, Beyer and Schmidt asserted that it would be questionable to draw any conclusions on the workings of the EMS that base themselves on the estimated coefficients of forward premium changes.

Here only the coefficients for Italy's short- and long-term and the coefficient of DM/NLG for the German short-term interest rate were under the accepted error probability of 0,05. This supports the notion from Beyer and Schmidt that the model could be inadequate and that the interest rate changes in the EMS are not reliably explained by this model. In the next section another type of test on the German dominance hypothesis is conducted.

5.2 Interdependence of Interest Rates

A country can maybe insulate its economy from outside shocks, but this is not the same as having an independent monetary policy, i.e. independent interest rates. This part examines the possible interdependencies between interest rates of the EMS countries, that is the extent to which the interest rate of one EMS country affects that of another one given the influence of the US. If

German dominance holds, German interest rates will influence the interest rates of the others, but are not influenced by them. Besides France, Italy, the Netherlands and Germany this test was also done for Belgium and Finland. The data set are the same as in the previous section.

5.2.1 Methodology

A test of omitted variables examines the effects of the monetary policy conducted by one EMS member on another member. In the analysis, a set of variables is added to an existing equation in attempt to improve the explanatory power of the equation. First, the interest rate of an EMS country is explained by its own past and the past US interest rate changes (equation (5.3)). Second, the previous changes of the interest rate of another EMS country are added (equation (5.4)). The purpose of adding another EMS country is to reveal if any, a significant contribution to the explanation of the dependent variable. The following equations are used (De Grauwe 1991, 220):

$$\Delta r_X = \sum \alpha_{iX} \Delta r_{X,t-i} + \sum \beta_{iX} \Delta r_{US,t-i} \tag{5.3}$$

$$\Delta r_X = \sum \alpha_{iX} \Delta r_{X,t-i} + \sum \beta_{iX} \Delta r_{US,t-i} + \sum \chi_{iX} \Delta r_{Y,t-i} \tag{5.4}$$

Here Δr_X and Δr_Y are the changes in the interest rates of the EMS countries X and Y and Δr_{US} is the interest rate change in the US. Likelihood ratios are again used. If the probability of the likelihood ratio is 0,05 or below, the omitted variables do add explanatory power to the first regression. If explanatory power increases with equation (5.4), it can be said that r_Y causes r_X. The test is done also for sub-periods used in the breakpoint test to see if the results change after a certain point in time. For example if German dominance is more visible in France or Italy after 1990, when they abolished capital controls.

5.2.2 Results

Table 5.3 shows the results for France. The short-term French interest rates are mostly caused by Germany with another influence coming from the Netherlands. As can be seen from the table Germany seems to have a greater effect, since the probability of the likelihood ratio, when German rates are added is smaller than when Dutch rates are brought into the equation. The Italian interest rate has no influence. It would appear that also this test confirms the ineffectiveness of the capital controls in France. The long-term rates seem to be determined by the US alone and adding the German rate has no effect.

Table 5.3 Probabilities of Likelihood Ratios for French Interest Rates.
Omitted variables Germany, Italy and the Netherlands.

France	Germany	Italy	Netherlands
Short-term	0,0007*	0,325	0,007*
Long-term	0,723	-	-

* significant at the 5% level.

The results for the Italian interest rates are given in table 5.4. Capital controls were meant to shelter Italy from outside influences. They seem to have functioned more effectively with the long-term rates, while the previous period US short-term interest rate is significant in explaining the Italian rate in both equations. Neither German nor French short-term interest rates improve the explanatory power. The importance of the long-term US rates is not seen in Italy, in contrast to the others. The long-term rate is protected from German influences as well. After 1990 the results change dramatically. Whereas the US short-term rate is still significant, the probability of the likelihood ratio implies that Germany helps explain the changes of the Italian short-term rates. The same development can be seen in the long-term rates. The earlier insulated interest rates are now affected by Germany, but the US rate is not significant in explaining the changes in the Italian long-term rate here either.

Table 5.4 Probabilities of Likelihood Ratios for Italian Interest Rates.
Omitted variables Germany and France for 1985 - 1990 and 1990 - 1996.

Italy / Italy after 1990	Germany	France
Short-term	0,105 / 0,002*	0,300
Long-term	0,342 / 0,046*	-

* significant at the 5% level.

Table 5.5 provides the results for the Netherlands. Previous own changes explain the current changes in Dutch interest rates in equation (5.3). The probability of the likelihood ratio of adding Germany is well under 0,05 and Germany is significant in explaining the Dutch interest rate in equation (5.4). The French interest rate does not add to the explanatory power. As with France the long-term rate in the Netherlands is explained by the US, but Germany is of influence in the second equation. Also adding France brings a probability close to the significant level. This confirms the close connection between the German and Dutch monetary policies.

Table 5.5 Probabilities of Likelihood Ratios for Dutch Interest Rates. Omitted variables Germany and France.

Netherlands	**Germany**	**France**
Short-term	0,0007*	0,808
Long-term	0,032*	0,056

* significant at the 5% level.

The outcome from the test for Belgium is shown in table 5.6. German influence on Belgian short-term rate is evident. The likelihood ratio is clearly under the probability of 0,05. Also, both German previous period interest rates are significant in explaining the Belgian short-term rate. The French rates do not add anything to the explanatory power. The Belgian long-term rates follow those of the others: the only significant variable is the previous period US rate and Germany does not bring an improvement to the equation.

Table 5.6 Probabilities of Likelihood Ratios for Belgian Interest Rates. Omitted variables Germany and France.

Belgium	**Germany**	**France**
Short-term	0,001*	0,138
Long-term	0,601	-

* significant at the 5% level.

Finland as one of the new members in the EMS shows interesting evidence of the German dominance. The Finnish markka, has almost always been tied to another currency or currency basket. In June 1991 a fixed rate of the markka relative the ECU was formed. This peg was not very long lasting: in November of the same year the markka was devalued and in September 1992, during the EMS currency crisis, the markka was also allowed to float. This floating ended in October 1996, when Finland joined the ERM. The results for the short-term rates (long-term rates were not available) show that adding Germany to the equation for 1985 - 1996, does not add the explanatory power of the equation. When only the period after the floating decision of September 1992 is included in the test, the probability of the likelihood ratio becomes significant (0,0001). The previous German interest rate change is significant in explaining the Finnish interest rate changes. It can be concluded that German dominance does not limit itself just to the EMS. For Finland this may have provided a good basis for the entrance to the currency mechanism that followed at a time, when inflation was well under two per cent and the short-term interest rate differential with Germany had disappeared a few days earlier.

Germany is not influenced by the other countries, as should be the case if German dominance holds. The results can be seen in Table 5.7. Only the previous German interest rate change is significant in explaining the short-term equations. The long-term rate is determined by the previous US interest rate change, whereas adding the other European variables brings no change. Therefore, these results support the notion of Germany conducting an independent monetary policy.

Table 5.7 Probabilities of Likelihood Ratios for German Interest Rates. Omitted variables France, Italy, the Netherlands and Belgium.

Germany	France	Italy	Netherlands	Belgium
Short-term	0,6807	0,3058	0,2089	0,3899
Long-term	0,5423	0,0769	0,0534	0,1493

* significant at the 5% level.

5.2.3 Discussion

The results from this test show support in favor of the German dominance hypothesis. All of the short-term rates - the Italian after 1990 and the Finnish after 1992 - received a value for the probability of the likelihood ratio that was clearly significant, when Germany was added in the equation. For the long-term similar results were achieved only for the long-term rates in the Netherlands and in Italy after 1990. It seems that Germany influences the short-term rates in Europe and this power is not limited to the EMS. Additionally, it appears that this influence has increased in the nineties. In Italy abolishing the capital controls started a period, where German interest rates were determinant to the Italian rate, which influence has not been diminished by floating of the lira. This suggests that allowing more freedom for the exchange rate, may attain more influence from Germany. The German dominance observed in the Finnish rate after the floating of the Finnish markka supports this notion. Based on this test it can be concluded that the EMS, at least to some extent, is a DM-zone.

6 A CREDIBILITY ADJUSTED TEST ON GERMAN DOMINANCE

In this chapter further tests are done with interest rates in an attempt to prove the German dominance hypothesis. Earlier research has either examined the credibility of the system or then the monetary policy movements without taking into account the credibility effect. This credibility adjusted test examines the effect of credibility on the German dominance hypothesis by removing poor credibility from the interest rate series. It does not, however, consider how credibility may influence the conduct of monetary policy.

Most of the studies discussed earlier, except for Kirchgässner and Wolters, Ranki and Siklos and Wohar, ended their examination period in 1992 before the exchange rate bands were widened in 1993, which has given the participants more freedom in their monetary policies. It could be assumed that since then the credibility of the system and the fixity of the exchange rates have improved. When interest rates are considered, most of the shocks can now be absorbed by the exchange rate instead of the interest rates, which should have now stabilized.

As mentioned above the subject of analysis here is interest rates and the countries analyzed are Germany, Belgium, Denmark, Finland, France, Ireland, Italy, the Netherlands and Spain. First, the credibility of the exchange rate bands is tested. For this the simplest test from Svensson is used, where a rate-of-return band is formed for the interest rates according to the maximum and minimum expected rate of depreciation of the exchange rate within the fluctuation band. Then, the interest rates that were under or above - which was more common - the rate-of-return band were replaced with the bound of the band. Since the test of the credibility of the DM bands covered the whole period they were chosen over the ECU bands to clean the interest rates. Finally, German dominance was tested with the original and the "credible" interest rates. The results received with the adjusted interest rates were compared with those of the original interest rates to see the effect of credibility on the asymmetry hypothesis.

The co-integration procedure has been widely used to test the convergence of the interest rates implied by the German dominance hypothesis. The analysis that uses most recent data is that from Siklos and Wohar, where the last data sample is from July 1996. The amount of data after the widening of the bands in August 1993 is not sufficient to draw conclusions on how the system has been affected by this change. Here, the data set used go from April 1979 to June 1997, and besides the whole period two sub-periods are examined: May 1987 - June 1997 and August 1993 - June 1997.[16] Another difference with the earlier co-integration analysis is - as explained above - the use of interest rate data that is cleaned of poor credibility. Before conducting the co-integration procedure, the order of integration of the variables is tested. Last, Granger causality tests are conducted with both the original and credibility adjusted rates.

The data are monthly and were mostly obtained from OECD Main Economic Indicators and Bank of Finland statistics through the database of ETLA (Elinkeinoelämän Tutkimuslaitos). The 3-month interest rates used were respectively the treasury bill rate for Belgium and the interbank rate for Denmark and Italy. This was available for Denmark only from January 1987 replacing for the periods after the official rate used for the whole period. For Ireland and Spain the call money rate was employed and for Germany, Finland, France and the Netherlands respectively the Fibor, the Helibor, the Pibor and the Aibor. The ECU interest rate is a composite basket of the ECU interest rates excluding the interest rates of the United Kingdom and Greece. The spot exchange rates relative the Deutschmark and the ECU were calculated as cross rates by using end of month US dollar spot rates, which were obtained from IMF's Financial Statistics besides ETLA's database. The central rates against the ECU were taken from European Economy Annual Economic Report and Suomen Pankin Rahoitusmarkkinat Tilastokatsaus. Cross rates were again used to obtain DM exchange rates. The econometrics program used in testing for unit roots, co-integration and Granger causality was RATS.

6.1 Svensson's Simplest Test

The simplest test is performed to reveal poor credibility of the exchange rate by using interest rates. It measures the credibility of the exchange rate policy in a system of target zones with the difference between domestic and foreign interest rates. With exchange rate bands the exchange rate can appreciate and depreciate a certain amount inside the band, but can not move outside this tube. Foreign interest rates are given, therefore the bounds of the band define a rate-of-return band around

[16] The start of the period, May 1987 - June 1997, was chosen based on the existence of the Finnish Helibor interest rate, which was established in May 1987, more than the Basle-Nyborg agreement in September 1987.

the foreign interest rate for the domestic interest rate. If the domestic interest rate falls outside these bounds, the exchange rate commitment is not credible. Full arbitrage is assumed.

Credibility is tested against the bilateral DM exchange rates as well as the ECU rates. The test on the Deutschmark bounds covers the whole period, whereas the ECU credibility could only be tested after January 1984 due to the availability of the ECU composite interest rates. Attention is also paid to the exchange rate band, i.e. whether the spot exchange rate is within the fluctuation band. The fluctuation band is defined symmetric around the central rate, but in practice the bounds are slightly asymmetric, because the upper bound for e.g. the French franc has to equal the lower band for e.g. the Deutschmark, that is [(1 + 0,15) * FF/DM] ≠ [(1 + 0,15) * DM/FF]. Therefore, the fluctuation bounds are +16,12% and -13,88% in case of a 15% band (Mattila 1997, 25).[17]

The time period goes from April 1979 until June 1997. Since Spain only joined in June 1989 and Italy exited in September 1992 to rejoin in November 1996, their credibility is examined only during time of participation. Finland is not included in the credibility test due to its short attendance in the ERM.

6.1.1 Methodology

A target zone sets limits to the movement of the exchange rate:

$$S^L < S_t < S^U, \tag{6.1}$$

where S_t is the spot exchange rate at the moment t and S^L and S^U are the lower and upper bounds of the exchange rate band. A foreign τ-month investment made at moment t yields annually in domestic currency:

$$R_t^\tau = (1 + i^{*\tau}_t)\,(S_{t+\tau} / S_t)^{12/\tau} - 1, \tag{6.2}$$

[17] For the 2,25% band the bounds are calculated as +2,28% and -2,22% of the central rate and for the 6% band as +6,19% and -5,18%.

where $i^{*\tau}_t$ is the foreign annual interest rate for an τ-month investment in foreign currency at moment t and $S_{t+\tau}$ is the exchange rate at the moment $t + \tau$. The yield of the foreign investment in domestic currency must lie inside a band, which is obtained by combining (6.1) and (6.2):

$$R_t^{\tau L} \leq R_t^{\tau} \leq R_t^{\tau U}. \tag{6.3}$$

The bounds are calculated as:

$$R_t^{\tau L} = (1 + i^{*\tau}_t)\,(S^L / S_t)^{12/\tau} - 1 \text{ and} \tag{6.4}$$

$$R_t^{\tau U} = (1 + i^{*\tau}_t)\,(S^U / S_t)^{12/\tau} - 1. \tag{6.5}$$

Assumed that all arbitrage opportunities between the currencies have been used, the domestic interest rate, i_t^{τ} (at the same time for the same maturity) must also lie within the band. If it were above the upper limit, the yield on a domestic investment would be higher than the highest possible yield on a foreign investment, therefore it would be possible to make a profit without risk by taking a loan abroad and investing it in the home country. When all arbitrage possibilities have been used, the domestic interest rate can be outside the rate-of-return band only if the exchange rate is expected to move outside the band. Therefore, if the domestic interest rate is outside the rate-of-return band, the exchange rate policy is said to be non-credible.[18]

6.1.2 Results

The results reveal the significance of the width of the fluctuation band. With a wider band the exchange rate was always credible. This goes for the 6 per cent band used by Italy from the start of the period and by the later joiners Great Britain, Spain and Portugal (out of which only Spain is examined here) as well as for the 15 per cent band used after August 1993. Therefore, the most interesting results can be found with Belgium, Denmark, France, Germany, Ireland and the Netherlands, who all have been members during the whole existence of the ERM and have used the

[18] This section is based on Svensson (1991, 3 - 5) and Marviala (1993, 12 - 14).

2,25 per cent band. The results are presented with the graphs of the respective interest rates and rate-of-return bands.[19]

Figure 6.1 shows the results for the Belgian interest rate and the DM rate-of-return band. Belgium has experienced several periods of poor credibility that have ranged from one to eight months. These periods concentrated on the early years of the ERM, therefore they are only visible with the DM bands. Nine of the eleven realignments before the Basle-Nyborg agreement were preceded by a non- credible commitment in Belgium. The Belgian franc had been weak from the start, but the Belgian authorities were reluctant to devaluate the currency in the first realignments and later on problems were caused by the Belgium - Luxembourg Economic Union (BLEU). Luxembourg, whose economy was in better shape, opposed to realigning the common currency (Gros and Thygesen 1992, 76). In the end of the eighties the credibility towards the DM improved: in 1988 and 1989 the Belgian rate was above the upper ECU band for several months, whereas it came out of the Deutschmark band only in one month. Coming to the 1990s Belgian credibility with both bands has enhanced, which suggests that also Belgium has emerged towards the hard currency option offered by the Bundesbank, which according to Weber was the case with France and Ireland (1991, 59).

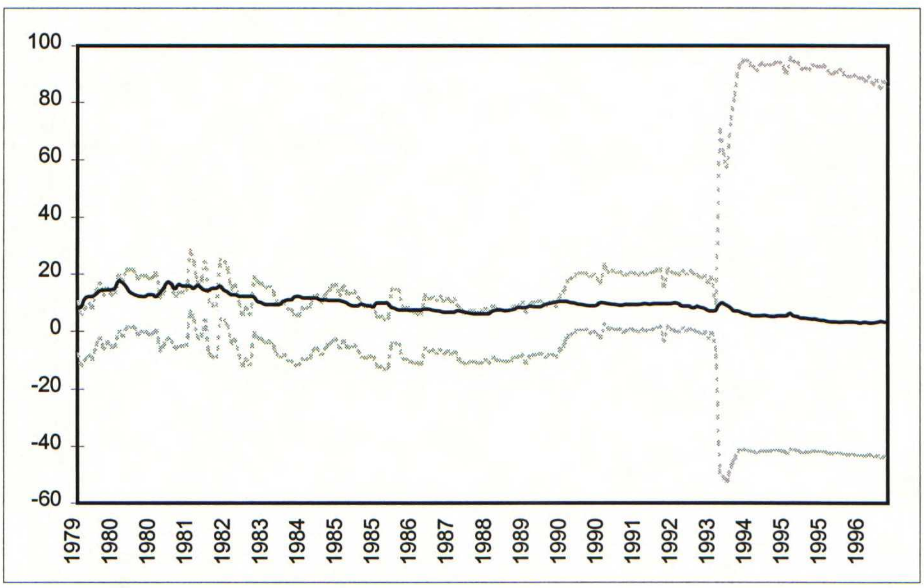

Figure 6.1 The Belgian Treasury Bill Rate and the Rate-of-Return Band

[19] With the exception of Germany, for whom the ECU band is used, only graphs of the DM bands are presented to conserve space.

For Denmark the only available interest rate from the start of the period was the official discount rate, which does not reflect the level of interest rates set by the markets. The interbank rate, which can be considered to be a market interest rate, was used only after January 1987. These interest rates are given in figure 6.2 with the Deutschmark band. Even though the interest rate was set by the authorities poor credibility of the Danish exchange rate commitment can be seen in the interest rate from time to time: with the DM band right after the start of the ERM as in Belgium with the difference being that Denmark initiated the first two realignments and devaluated against the Deutschmark. Most of the year 1986 witnessed the official rate above the DM band. The interbank rate was above the upper bound of the DM rate-of-return band on several occasions, among others the whole year of 1989, when poor credibility with the official rate was only observed in April. The ECU band was non-credible only during the first half of 1989, but with both interest rates. Interestingly the poor credibility of the market rate rarely preceded a realignment. The 1992 crisis can only be seen with the credibility of the interbank rate, whereas the 1993 crisis witnessed both interest rates above the DM rate-of-return band. The ECU commitment during the crisis seems to have been credible, except for October 1992, when both interest rates were below the band indicating a strong crone. The widening of the fluctuation band helped bring interest rates down with the exchange rate depreciating strongly.

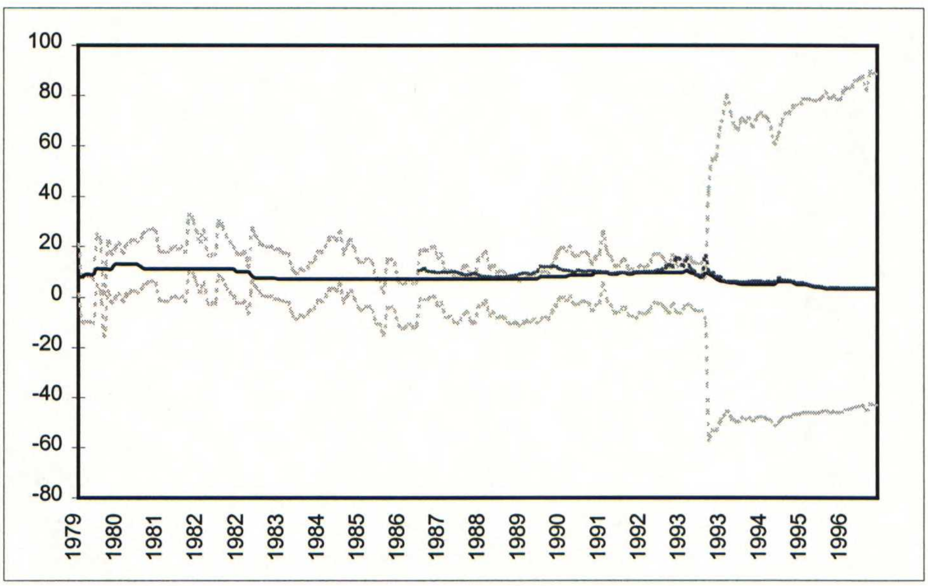

Figure 6.2 The Danish Official Discount Rate and the Interbank rate (starting 1/1987) and the Rate-of-Return Band

Figure 6.3 presents France's market interest rate and the DM rate-of-return band. The French credibility was clearly better than that of Belgium or Denmark. Periods, when the Pibor was above the rate-of-return band lasted only for one or two months, but this, considering the Deutschmark band, often before a realignment. The government change of 1981 in France brought the first periods of poor credibility. A realignment between the franc and the Deutschmark soon followed, which started a period of realignments that could be characterized with divergence in the politics and performance of the largest ERM members (Gros and Thygesen 1992, 75). The periods of poor credibility concentrated in the end of the eighties, when the option of realignment was given up in the Basle-Nyborg agreement. They were accompanied with the ECU exchange rate outside the fluctuation band, whereas the DM rate mostly stayed within the band. It follows that the option of realignment was essential in restoring French credibility, whereas the ineffectiveness of the French capital controls suggested by Herz and Röger (1992, 1423), is also proven here. In the nineties France has moved towards Germany as suggested by Weber (1991, 59), thus improving the credibility of its exchange rate commitment.

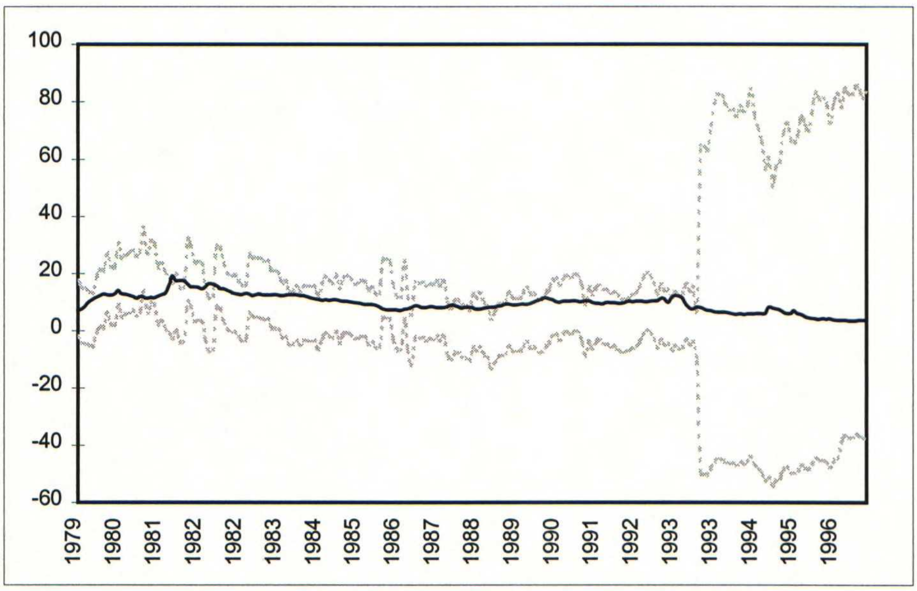

Figure 6.3 The French Pibor Rate and the Rate-of-Return Band

The Irish interest rate together with the Deutschmark rate-of-return band is illustrated in figure 6.4. The periods of poor credibility in relation to the DM closely followed those of Belgium and to a lesser extent Denmark and France. Therefore, these periods again preceded most realignments, although Ireland was not the initiating party. Ireland together with Italy had the highest inflation rate and the realignments, especially in the first half of the eighties, did not devalue the currency to the full extent of excess of inflation with Germany. This loss of competitiveness was to some extent sustainable, due to the appreciation of the currency of Ireland's major trading partner, the UK. After the sterling depreciated strongly in 1986, the situation became unbearable and Ireland asked for a realignment in August 1986 (Gros and Thygesen 1992, 84). Better credibility was obtained with the ECU bands. The first four months of 1987 experienced poor credibility with both bands, after which the credibility improved until the 1992 crisis. In November 1992 the Irish interest rate reached 55% and in January 1993 97%, but stabilized thereafter and did not react to the 1993 crisis.

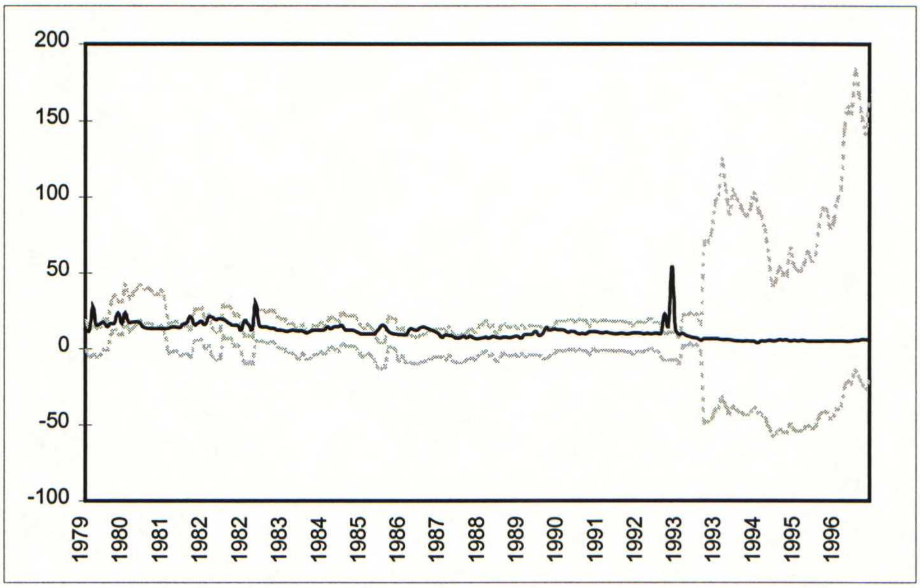

Figure 6.4 The Irish Call Money Rate and the Rate-of-Return Band

Figure 6.5 shows the Italian interest rate with the DM rate-of-return band. The wider band after October 1996 is not illustrated for the earlier movements to be more visible. Italy used the 6 per cent band until 1990, when it moved to using the narrower 2,25 per cent band. Its commitment to the wider band was credible based on this test. The exchange rate did not reach the bands, which explains the result of the intervention studies that Italy never intervened at the margin, e.g. Giavazzi and Giovannini (1988, 66). Italy was however involved in several of realignments, which could be explained by the loss of competitiveness caused by the inflation differential with Germany. The narrower band combined with high Italian interest rates led to poor credibility in fall of 1992 and then to Italy's exit from the system. The credibility of the narrower band lasted for a very short period of time, which suggests that Italy's credibility is not very strong, when the movement of the exchange rate is restricted.

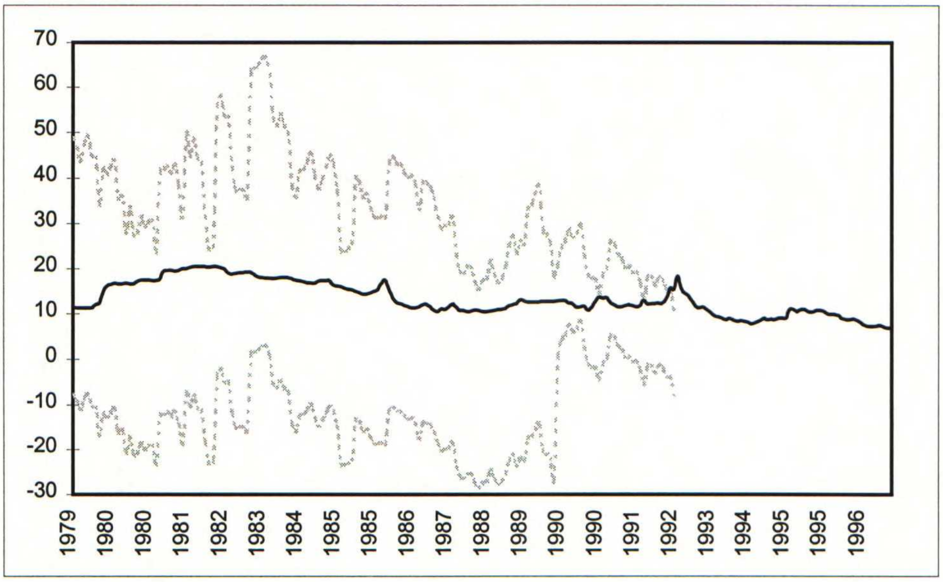

Figure 6.5 The Italian Interbank Rate and the Rate-of-Return Band

The interest rate and the Deutschmark rate-of-return band for the Netherlands are shown in figure 6.6. In contrast to the totally credible Dutch DM bands, both the upper and lower ECU bands together with the ECU exchange rate band were violated at some point. The Dutch authorities have aimed the guilder to be considered as a close substitute to the Deutschmark, but especially in the beginning of the ERM this was constrained by the reluctance to break up the fixity of rates with the Benelux currencies (Gros and Thygesen 1992, 73). Periods of guilder strength, which always occurred simultaneously with periods of strong D-mark, took place in the end of 1985 - beginning of 1986 and during the EMS crisis in 1992. This is in accordance with Weber's bipolar theory,

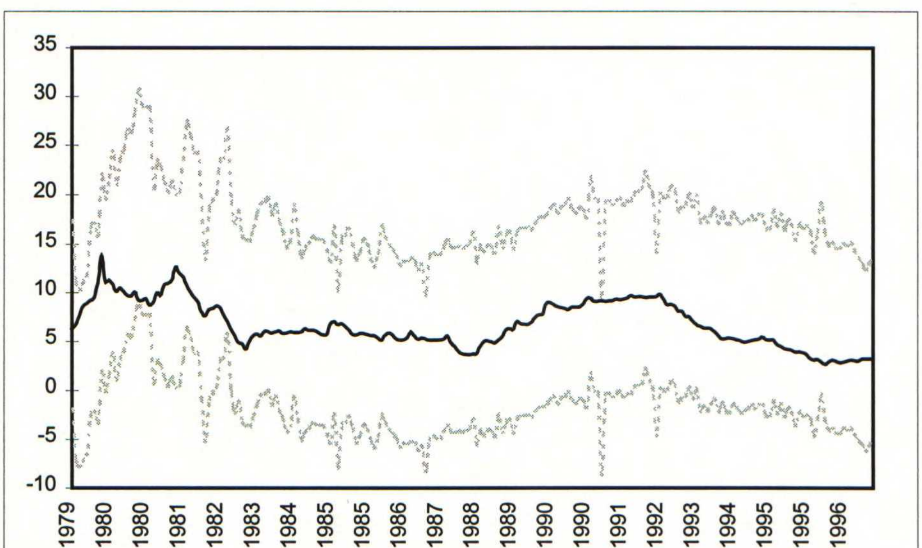

Figure 6.6 The Dutch Aibor Rate and the Rate-of-Return Band

where Germany and the Netherlands in practice already form a monetary union. The close relation of Germany and the Netherlands also led them to agree to keep the guilder/Deutschmark exchange rate within the 2,25 per cent band after the widening of the bands in August 1993. This rate was used to calculate the DM rate-of-return band, which was credible also during turbulence in the EMS.

The Spanish interest rate with the DM rate-of-return band are given in figure 6.7. Spain joined the system in June 1989 with the six per cent band, which it used until August 1993, when it moved to using the 15 per cent band with the others. The Spanish call money rate stayed within both rate-of-return bands, although it did participate in realignments. For instance, the Mexican peso crisis in the end of 1994 led to the devaluation of the Spanish peseta together with the Portuguese escudo.

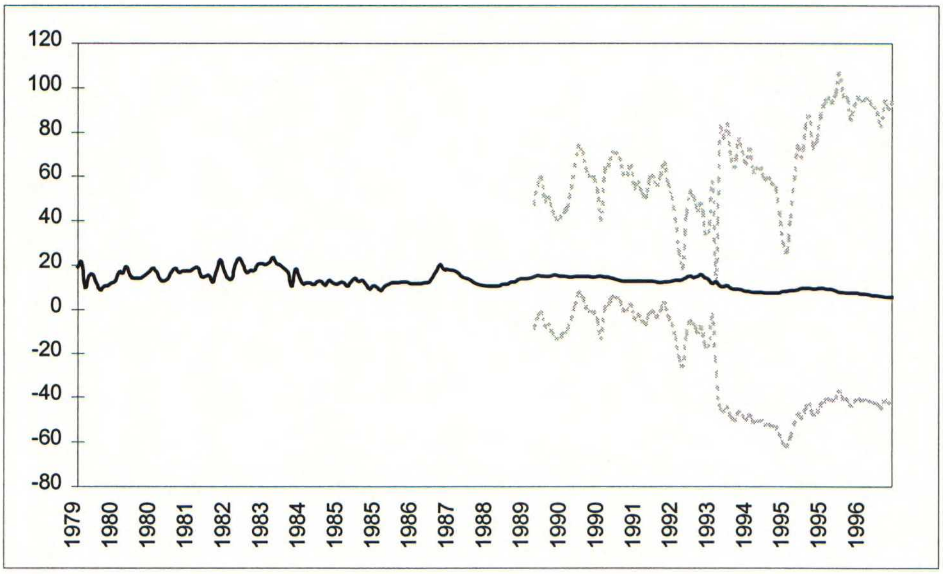

Figure 6.7 The Spanish Call Money Rate and the Rate-of-Return Band

Figure 6.8 illustrates the German interest rate together with the ECU rate-of-return band. All EMS realignments have involved a devaluation of another EMS currency and a revaluation of the Deutschmark. The non-credible German commitment towards the ECU has thus always been on the lower bound of the rate-of-return band. The DM strength has often been brought into the EMS from international currency markets. For example the realignment of January 1987 was preceded by fall of the US dollar, which caused a flow of funds into the Deutschmark. The strong DM was accompanied with weak EMS currencies, which were all below the DM rate-of-return band. This realignment was the last one before the Basle-Nyborg agreement and before the 1990s.

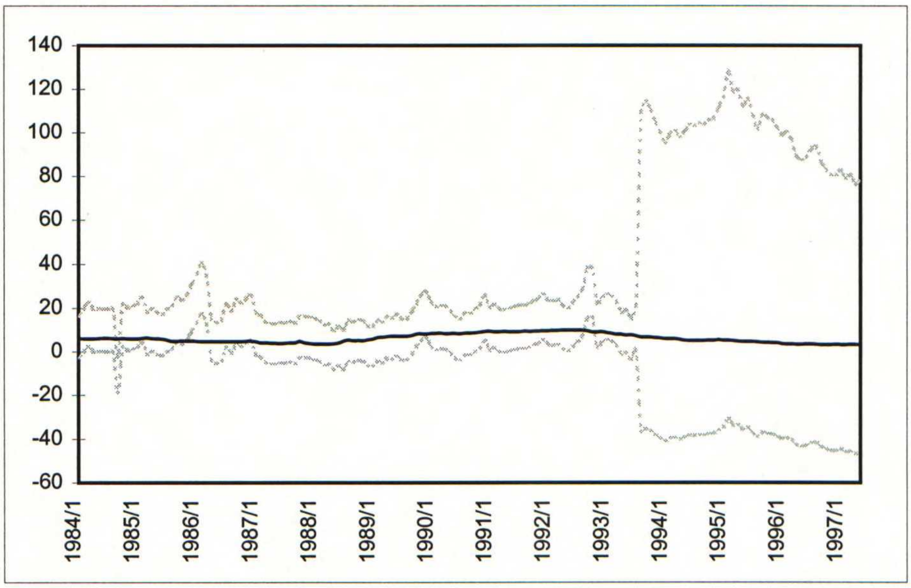

Figure 6.8 The German Fibor Rate and the Rate-of-Return Band

The EMS before the crisis is often divided in three periods based on the number of realignments (for example Gros and Thygesen 1992, 67 - 72). The period from the start until realignment of March 1983 was characterized with frequent realignments. During the period that followed and lasted until the Basle-Nyborg agreement in September 1987 the realignment were smaller and less frequent. The period of no realignments lasted the rest of the eighties and until the EMS crisis. After 1993 the system has stabilized, which can be credited to the wider fluctuation bands. In the beginning of the eighties the DM band suffered from poor credibility, which improved after the Basle-Nyborg agreement, whereas the ECU credibility worsened. This may be an implication of growing importance of Germany in the system. It also supports the notion that realignments facilitated symmetry in the system. Removing this freedom makes Germany's role more important and the other members thus aim for credibility of the DM band over the ECU.

6.2 Stationary and Non-stationary Time Series

Testing for the presence of unit roots in the time series is a fairly new area in econometrics. Therefore, it is not surprising that the earliest research on the German dominance hypothesis has been criticized for failing to take into account the non-stationarity of the time series used. This was the one of the criticisms of Beyer and Schmidt (1992) for De Grauwe's model (1991), where the results seemed to be biased. Fratianni and von Hagen (1990) have also been criticized for the same reason, for example Kirchgässner and Wolters state that Fratianni and von Hagen (correctly) assumed that the time series were non-stationary and they therefore used VAR models in first differences, which, however, may have disregarded long-run influence of Germany on the others (1993, 774). Hence, testing for the presence of a unit root in the time series is essential.

6.2.1 Methodology

There are important differences between stationary and non-stationary time series. A stationary series tends to return to its mean value and fluctuate around it within a constant range, i.e. it has a finite variance, while a non-stationary series has a different mean at different points in time. Therefore, the concept of a mean is not really applicable and the variance increases with the sample size. Models containing non-stationary variables will often lead to a problem of spurious regression, whereby the results obtained suggest that there are statistically significant relationships between the variables in the regression model when in fact all that is obtained is evidence of contemporaneous correlations rather than meaningful causal relations.

The question of whether a variable is stationary is related to the presence of a unit root in the time series. If a series must be differenced d times before it becomes stationary, then it contains d unit roots and is said to be integrated of order d, denoted I(d). For example, a series that becomes stationary upon being differenced once, must contain one unit root and it is thus integrated of order one - I(1). Opposed to a random walk, where first differences are stationary, suppose that a series is generated by the following process:

$$y_t = \rho_1 y_{t-1} + u_t, \tag{6.6}$$

where the current values of the variable y_t depend on last period's value y_{t-1} plus a disturbance term u_t, the latter encapsulating all other random, i.e. stochastic, influences. The variable y_t will be stationary, when $|\rho_1| < 1$ and non-stationary, when $|\rho_1| \geq 1$. If $|\rho_1| = 1$ y_t is I(1) and if $|\rho_1| > 1$, y_t is integrated of a order higher than one. This can be seen from:

$$y_t - y_{t-1} \equiv \Delta y_t = (\rho_1 - 1)\, y_{t-1} + u_t, \tag{6.7}$$

where Δy_t is no longer stationary: it depends not only upon the stationary process u_t, but also upon the non-stationary process y_{t-1}, since $(\rho_1 - 1) > 0$. Hence an AR(1) process with a coefficient of 1 is I(1), but the same process with a coefficient of 1,01 is not, since differencing will not reduce this process to stationarity.

There are several ways of testing for the presence of a unit root. The most common ones are the Dickey-Fuller and Phillips-Perron methods. Dickey and Fuller (1979, 1981) consider three different models that can be used to test for the presence of a unit root:

$$y_t = \rho_a y_{t-1} + u_t, \tag{6.8}$$

$$y_t = \mu_b + \rho_b y_{t-1} + u_t, \tag{6.9}$$

$$y_t = \mu_c + \gamma_c t + \rho_c y_{t-1} + u_t. \tag{6.10}$$

The first is like a pure random walk model, the second adds a constant or a drift term, and the third includes both a drift and a linear time trend. The null hypothesis is that the series contains a unit root, i.e. H_0: $\rho_i = 1$ for i = a, b, c, against the alternative of stationarity, i.e. H_1: $\rho_i < 1$ for i = a, b, c. The standard approach to testing is to construct a *t*-test; however the statistic does not follow a standard *t*-distribution, but a Dickey-Fuller distribution. The methodology is the same regardless of which of the three forms of the equations is estimated. Nevertheless, the critical values do depend on whether an intercept and/or time trend is included in the regression equation. The augmented Dickey-Fuller test adds an unknown number of lagged first differences of the dependent variable to capture the auto-correlated omitted variables that would otherwise, by default, enter the error term, u_t.

The alternative for the augmented Dickey-Fuller test is the method from Phillips and Perron (1988) that assumes a non-parametric correction to the *t*-test statistic to account for auto-correlation, rather than taking account of extra terms in the data generating process by adding them to the regression model. The procedure modifies the statistics after estimation in order to consider the effect that auto-correlated errors will have on the results, whereas the Dickey-Fuller method aims to retain the validity of the tests based on white-noise errors in the regression model by ensuring that those errors are indeed white noise. Phillips-Perron also uses three regression models, where the only difference is with the last equation: (6.11) differs from (6.10) used in Dickey-Fuller by centering the trend term. Thus, (6.10) is here written as:

$$y_t = \mu_c + \gamma_c(t - T/2) + \rho_c y_{t-1} + u_t. \tag{6.11}$$

To test the significance of ρ_i, the *t*-statistics are adjusted to reflect auto-correlation in the corresponding u_t series. Since the Phillips-Perron procedure available in RATS always includes a constant the critical values are the same as those for the Dickey-Fuller equation (6.9).[20]

6.2.2 Results

The order of integration of all the interest rate series was tested using both the Dickey-Fuller and Phillips-Perron statistics. The null hypothesis was that the interest rate series are integrated of order one, I(1), and will thus have to be differenced once to achieve stationarity. Differences rise in regard to the time period used as well as the time series being one of the original interest rates or the credibility adjusted ones for Belgium, Denmark, France, Ireland and Italy. Due to the exceptionally high interest rates in Ireland in November 1992 and January 1993 (55 and 96,8 per cent respectively) a dummy variable was used for the original interest rates to exclude this effect from the results. The tables presenting the results contain two statistics of both tests: one with two lags and the other with two lags as well as a trend. The other statistics with zero, one and four lags are found in the appendix. The critical values are -2,88 and -3,43 for a sample size of 250, which comes close to the size of the whole sample, -2,89 and -3,45 for 100 observations, which are used for May 1987 - June 1997 and for the last period -2,93 and -3,50 with a sample of 50 (Harris 1995, 156).

The results for the whole period original and adjusted interest rates and their first differences are found in tables 6.1, 6.2 and tables 1 and 2 in the appendix. There is some variation to the results. A series where seven out of the ten test values indicates the presence of a unit root, is considered non-stationary and vice versa.

[20] Based on Banerjee et al. (1993, 99 - 113), Enders (1996, 85 - 90) and Harris (1995, 14 - 19 and 27 - 34).

Table 6.1 Unit Root Tests for Levels of Data, 4/1979 - 6/1997.
Original (o) and adjusted (a) data with two lags / two lags and a trend.

Country		Dickey-Fuller		Phillips-Perron	
Germany		-1,262	-1,649	-0,928	-1,692
Belgium	**(o)**	-1,260	-2,900	-0,991	-3,681*
	(a)	-2,227	-4,220*	-2,497	-4,380*
Denmark	**(o)**	-0,657	-1,691	-0,490	-1,932
	(a)	-1,184	-2,286	-2,480	-4,007*
France	**(o)**	-1,297	-3,227	-1,008	-3,561*
	(a)	-0,962	-3,294	-1,411	-3,946*
Ireland	**(o)**	-4,491*	-5,214*	-11,016*	-12,622*
	(a)	-2,515	-4,976*	-3,558*	-7,383*
Italy	**(o)**	-1,046	-3,733*	-0,775	-3,236
	(a)	-0,808	-3,486*	-0,959	-3,439
Netherlands		-1,324	-1,939	-1,202	-1,990
Spain		-3,305*	-3,412	-3,425*	-4,587*

* presence of a unit root rejected (critical values -2,88 / -3,43).

Table 6.2 Unit Root Tests for First Differences of Data, 4/1979 - 6/1997.
Original (o) and adjusted (a) data with two lags / two lags and a trend.

Country		Dickey-Fuller		Phillips-Perron	
Germany		-8,972	-6,415	-10,356	-10,297
Belgium	**(o)**	-10,236	-8,892	-11,475	-11,499
	(a)	-9,948	-9,948	-16,036	-16,085
Denmark	**(o)**	-10,317	-7,896	-12,664	-12,725
	(a)	-12,327	-12,364	-25,813	-25,908
France	**(o)**	-9,761	-11,292	-11,128	-11,125
	(a)	-9,522	-9,580	-16,663	-16,786
Ireland	**(o)**	-10,702	-10,676	-36,415	-36,415
	(a)	-12,664	-12,635	-23,197	-23,201
Italy	**(o)**	-8,378	-7,666	-11,542	-11,544
	(a)	-7,836	-7,973	-19,213	-19,412
Netherlands		-9,364	-7,059	-12,942	-12,991
Spain		-14,825	-10,796	-17,049	-17,323

* presence of a unit root accepted (critical values -2,88 / -3,43).

The hypothesis of a presence of a unit root in levels of the original rates is proven for Germany, Belgium, Denmark, France, Italy and the Netherlands, whereas no unit roots are found for Ireland and Spain. The outcome for the Irish rate was the same, whether a dummy was used or not. All first differences appear to be stationary. Therefore, it can be concluded that while the German, Belgian, Danish, French, Italian and Dutch interest rates are I(1), the Irish and Spanish interest rates are stationary - I(0). There is a slight change in the results of the adjusted Belgian, Danish, French, Irish and Italian rates. The French and Italian rates are still clearly I(1), whereas the levels of the

Belgian and Danish rates now show more statistics rejecting the presence of a unit root. Additionally, the Dickey-Fuller statistics of the Irish rate show more non-stationary values, while the Phillips-Perron is in favor of stationarity. However, the conclusion remains the same as with the original rates.

Table 6.3 Unit Root Tests for Levels of Data, 5/1987 - 6/1997.
Original (o) and adjusted (a) data with two lags / two lags and a trend.

Country		Dickey-Fuller		Phillips-Perron	
Germany		-0,665	-1,547	-0,510	-1,413
Belgium	**(o)**	-0,549	-1,877	-0,474	-1,673
	(a)	-0,431	-1,752	-0,557	-1,709
Denmark	**(o)**	-0,933	-1,879	-1,561	-2,719
	(a)	-0,854	-1,619	-1,165	-2,017
Finland		-0,697	-2,124	-0,670	-2,004
France	**(o)**	-0,553	-1,944	-0,596	-1,869
	(a)	-0,781	-1,913	-1,029	-2,114
Ireland	**(o)**	-3,778*	-3,852*	-9,415*	-9,550*
	(a)	-0,986	-1,559	-1,874	-2,131
Italy	**(o)**	-1,629	-2,539	-1,328	-2,297
	(a)	-0,891	-1,941	-1,872	-3,143
Netherlands		-0,546	-1,271	-0,340	-1,144
Spain		-1,407	-2,464	-1,905	-2,398

* presence of a unit root rejected (critical values -2,89 /-3,45).

Table 6.4 Unit Root Tests for First Differences of Data, 5/1987 - 6/1997.
Original (o) and adjusted (a) data with two lags / two lags and a trend.

Country		Dickey-Fuller		Phillips-Perron	
Germany		-4,845	-5,523	-7,973	-8,720
Belgium	**(o)**	-7,111	-7,366	-8,730	-8,885
	(a)	-7,274	-7,519	-11,214	-11,393
Denmark	**(o)**	-7,052	-7,069	-16,869	-16,943
	(a)	-6,230	-6,237	-13,906	-13,954
Finland		-6,677	-6,796	-7,416	-7,489
France	**(o)**	-6,790	-6,957	-8,840	-8,934
	(a)	-7,008	-7,110	-11,686	-11,771
Ireland	**(o)**	-12,204	-12,150	-58,616	-58,619
	(a)	-6,474	-6,454	-15,973	-15,969
Italy	**(o)**	-5,333	-5,360	-10,283	-10,361
	(a)	-6,492	-6,548	-18,345	-18,530
Netherlands		-4,510	-4,749	-7,889	-8,195
Spain		-3,542	-3,516	-9,633	-9,614

* presence of a unit root accepted (critical values -2,89 / -3,45).

Tables 6.3 and 6.4 present the results for the period from May 1987 to June 1997. The interest rates of Germany, Belgium, Denmark, France, Italy and the Netherlands are also in this time period I(1). The same result is achieved for Finland that was not included in the sample of the whole period as well as for the previously stationary Spanish interest rate. The presence of a unit root is rejected for the original Irish interest rate, while all of the adjusted rates, including the Irish one, are proven integrated of order one.

In the last sub-period, August 1993 - June 1997, there are some changes to the orders of integration. The results are presented in tables 6.5 and 6.6 for two lags as well as two lags and a trend. The results for zero, one and four lags are again found in the appendix (tables 5 and 6). The levels of the German, Finnish, French, Italian, Dutch and Spanish interest rate still fail to reject the presence of a unit root, whereas no unit roots are found with the Belgian rate. For Denmark and

Table 6.5 Unit Root Tests for Levels of Data, 8/1993 - 6/1997.
Original data with two lags / two lags and a trend for the period.

Country	Dickey-Fuller		Phillips-Perron	
Germany	-2,254	-2,137	-1,785	-1,515
Belgium	-3,688*	-4,106*	-3,508*	-2,417
Denmark	-1,656	2,590	-3,120*	-3,341
Finland	-1,711	-2,565	-0,959	-1,786
France	-1,053	-1,903	-1,491	-2,126
Ireland	-2,450	-1,943	-2,930	-2,690
Italy	-0,369	-0,585	-0,547	-0,770
Netherlands	-2,020	-1,353	-1,858	-1,142
Spain	-1,659	-1,919	-1,009	-1,327

* presence of a unit root rejected (critical values -2,93 / -3,50).

Table 6.6 Unit Root Tests for First Differences of Data, 8/1993 - 6/1997.
Original data with two lags / two lags and a trend for the period.

Country	Dickey-Fuller		Phillips-Perron	
Germany	-3,514	-3,755	-5,120	-5,450
Belgium	-3,343	-3,588	-6,167	-7,239
Denmark	-2,938	-2,819*	-6,016	-6,372
Finland	-4,195	-4,141	-4,509	-4,508
France	-3,642	-3,596	-6,758	-6,752
Ireland	-3,883	-4,361	-11,333	-12,226
Italy	-2,993	-3,221*	-6,231	-6,456
Netherlands	-3,104	-3,295*	-4,768	-5,105
Spain	-2,208*	-2,211*	-6,294	-6,302

* presence of a unit root accepted (critical values -2,93 / -3,50).

Ireland the result is dubious: the values are divided between rejecting and accepting the presence of a unit root. All of the first differences reject the presence of a unit root, although there are several values indicating a higher order integration. Consequently, it is concluded that while the German, Finnish, French, Italian, Dutch and Spanish interest rates are I(1) and the Belgian rate is stationary, no clear decision can be met for the Danish and Irish rates. This leads to a speculation about the sufficiency of the data sample, i.e. whether the amount of data is adequately large for conclusions to be made based on it.

Cleaning the time series of poor credibility does not bring any decisive changes into the order of integration of the variables. On one hand, the whole period adjusted Belgian and Danish interest rates showed more signs of rejecting the presence of a unit root. On the other hand, when the Irish rate is adjusted in the later period, it becomes I(1) as the others. Since the later data set also changed the Spanish rate from I(0) to I(1), time period is maybe more relevant considering the order of integration. This conclusion should not be extended to the last sub-period, where the size of the data set may have caused bias in the test. The same order of integration of the credibility adjusted interest rates in the sample from May 1987 to June 1996 might be credited to the EMS, where the interest rates - economies - have converged. The co-integration tests in the next section examine the convergence of interest rates in the EMS.

6.3 Co-integration

Co-integration procedures have become widely used in econometrics. They have clearly been the most used way to test the German dominance hypothesis in the 1990s. First, the theory of co-integration is explained combined with the two ways of testing for co-integration: the Engle-Granger two step procedure and the Johansen method. The second section provides the results for the different time periods.

6.3.1 Methodology

For series to be co-integrated, they must have comparable long-run properties. Consider two time series y_t and x_t, which are both I(d). In general, any linear combination of the two series will also be I(d); for example the residuals obtained from regressing y_t on x_t are I(d). If, however, there exists a vector β, such that the disturbance term from the regression, u_t, is of a lower order of integration, I(d-b), where b>0, then Engle and Granger (1987) define y_t and x_t as co-integrated of order (d,b). Thus, if y_t and x_t were both I(1), and $u_t \sim I(0)$, then the two series would be co-integrated of order CI(1,1).

The economic interpretation of co-integration is that if two (or more) series are linked to form an equilibrium relationship spanning the long-run, then even though the series themselves may contain stochastic trends, i.e. be non-stationary, they will nevertheless move closely together over time and the difference between them will be stationary. Thus, the concept of co-integration mimics the existence of a long-run equilibrium to which an economic system converges over time, and u_t can be interpreted as the dis-equilibrium error, i.e. the distance that the system is away from equilibrium at time t.

Granger representation theorem states that for any set of I(1) variables, co-integration and error-correction are equivalent representations. Formally, the $(n \times 1)$ vector $x_t = (x_{1t}, x_{2t}, \dots, x_{nt})'$ has an error correction representation if it can be expressed in the form:

$$\Delta x_t = \pi_0 - \pi x_{t-1} + \pi_1 \Delta x_{t-1} + \pi_2 \Delta x_{t-2} + \dots + \pi_p \Delta x_{t-p} + \epsilon_t, \qquad (6.12)$$

where π_0 is an $(n \times 1)$ vector of intercept terms with elements π_{i0}, the π_i are $(n \times n)$ coefficient matrices with elements $\pi_{jk}(i)$, π is a matrix with elements π_{jk} such that one or more of the $\pi_{jk} \neq 0$; and ϵ_t is an $(n \times 1)$ vector with elements ϵ_{it}. All variables in x_t are I(1). If there is an error correction representation of these variables as in (6.12), there is necessarily a linear combination of the I(1) variables that is stationary. Solving (6.12) for πx_{t-1} obtains:

$$\pi x_{t-1} = \Delta x_t - \pi_0 - \Sigma \pi_i \Delta x_{t-i} - \epsilon_t. \qquad (6.13)$$

Since each expression on the right-hand side is stationary, πx_{t-1} must also be stationary. π contains only constants, thus each row of π is a co-integrating vector of x_t. As each series x_{it-1} is I(1), $(\pi_{11}, \pi_{12}, \dots, \pi_{1n})$ must be a co-integrating vector for x_t. Hence, an error correction model for I(1) variables necessarily implies co-integration and vice versa.

In case of more than two variables, there may be more than one co-integrating vector. If there exist exactly r linearly independent co-integrating vectors with $r \leq n - 1$, then these can be gathered into an $(n \times r)$ matrix π. The rank of π, r, can be used to determine whether or not the variables in x_t are co-integrated and accordingly, it is called the co-integrating rank. If π has full rank, i.e. there are $r = n$ linearly independent columns, then the variables in x_t are I(0), while if the rank is zero, each element of π must equal zero and the system ought to be respecified in differences to achieve stationarity. In the intermediate case $0 < r < n$.

Consequently, there are two ways to test for co-integration. The Engle-Granger procedure aims to determine, whether the residuals of the equilibrium relationship are stationary, while the Johansen methodology examines the number of characteristics roots of π that are less than unity.[21]

The Engle-Granger Two-step Procedure

Engle and Granger (1987) have proposed a two-step estimator for models involving co-integrated variables. In the first step, the parameters of the co-integrating vector are estimated by running the static regression in the levels of the variables. In the second step, these are used in the error correction form. This procedure is convenient because the dynamics do not need to be specified until the error correction structure has been estimated.

Suppose two variables x_t and y_t, both I(1), are examined for co-integration. The long-run equilibrium relationship is of the form:

$$y_t = \beta_0 + \beta_1 x_t + e_t. \tag{6.14}$$

If the variables are co-integrated, an OLS regression yields a "super-consistent" estimator of the co-integrating parameters β_0 and β_1. If the variables are co-integrated, the series of the estimated residuals of the long-run relationship, $\hat{e}_t$, are stationary. The auto-regression of the variables is:

$$\Delta\hat{e}_t = a_1\hat{e}_{t-1} + \epsilon_t. \tag{6.15}$$

[21] Based on Banerjee et al. (1993, 136 - 146), Enders (1996, 151 - 156) and Harris (1995, 22).

The null hypothesis is that $a_1 = 0$; the residuals contain a unit root. If it is not possible to reject the null hypothesis, the hypothesis of no co-integration can not be rejected. The rejection of the null hypothesis implies that the residual sequence is stationary. Use of the Dickey-Fuller tables is not possible, since only the estimate of the error $\hat{e}_t$ is known, not the true e_t sequence. The appropriate test statistics are found in Engle and Yoo (1987). Given that both y_t and x_t are I(1) and that the residuals are stationary, it can be concluded that the series are CI(1,1).

If the variables are co-integrated, the residuals from the equilibrium regression can be used to estimate the error correction model. If y_t and x_t are CI(1,1), the error correction form is:

$$\Delta y_t = \alpha_1 + \alpha_y(y_{t-1} - \beta_1 x_{t-1}) + \Sigma\alpha_{11}(i)\Delta y_{t-i} + \Sigma\alpha_{12}(i)\Delta x_{t-i} + \epsilon_{yt} \qquad (6.16)$$

$$\Delta x_t = \alpha_2 + \alpha_x(y_{t-1} - \beta_1 x_{t-1}) + \Sigma\alpha_{21}(i)\Delta y_{t-i} + \Sigma\alpha_{22}(i)\Delta x_{t-i} + \epsilon_{xt} \qquad (6.17)$$

where β_1 is the parameter of the normalized co-integrating vector; ϵ_{yt} and ϵ_{xt} are white-noise disturbances, which may be correlated with each other and α_1, α_2, α_y, α_x, $\alpha_{11}(i)$, $\alpha_{12}(i)$, $\alpha_{21}(i)$, $\alpha_{22}(i)$ are all parameters.

The Engle-Granger procedure has several limitations. The estimation of the long-run equilibrium regression requires that one variable is placed on the left-hand side and the others are used as regressors. Co-integration should be invariant to the choice of the variable selected for normalization. Another problem comes if there are more than two variables, which indicates that there may be more than one co-integrating vector. The Engle-Granger methodology can not estimate multiple co-integrating vectors, in contrast to the Johansen procedure, which can estimate and test for the presence of multiple co-integrating vectors.[22]

The Johansen Procedure

The Johansen method is concerned with identifying the number of co-integrating vectors in a multivariate setting with a maximum likelihood procedure. Consider the n-variable first-order vector auto-regression (VAR) model:

[22] Based on Banerjee et al. (1993, 157 - 159), Enders (1996, 156 - 160) and Harris (1995, 52 - 57.)

$$y_t = A_1 y_{t-1} + \epsilon_t, \tag{6.18}$$

where y_t is the $(n \times 1)$ vector $(y_{1t}, y_{2t}, \ldots, y_{nt})'$; ϵ_t is the $(n \times 1)$ vector $(\epsilon_{1t}, \epsilon_{2t}, \ldots, \epsilon_{nt})'$; A_1 is an $(n \times n)$ matrix of parameters. Subtracting y_{t-1} from each side gives:

$$\Delta y_t = A_1 y_{t-1} - y_{t-1} + \epsilon_t = (A_1 - I)y_{t-1} + \epsilon_t = \pi y_{t-1} + \epsilon_t, \tag{6.19}$$

where I is an $(n \times n)$ identity matrix; and π is defined to be $(A_1 - I)$. The rank of π equals the number of co-integrating vectors. The number of distinct co-integrating vectors can be obtained by checking the significance of the characteristic roots of π. The rank of a matrix is equal to the number of its characteristic roots that differ from zero. Suppose we obtained the matrix π and ordered the n characteristic roots such that $\lambda_1 > \lambda_2 > \ldots > \lambda_n$. If the variables in y_t are not co-integrated, the rank of π is zero and all of these characteristic roots will equal unity. Since $\ln(1) = 0$, each of the expressions in $\ln(1 - \lambda_i)$ will equal zero if the variables are not co-integrated. Similarly, if the rank of π is unity, the first expression $\ln(1 - \lambda_1)$ will be negative and all the other expressions are such that $\ln(1 - \lambda_2) = \ln(1 - \lambda_3) = \ln(1 - \lambda_n) = 0$. The test for the number of characteristic roots that are insignificantly different from unity can be conducted using the following two test statistics:

$$\lambda_{trace}(r) = -T\Sigma\log(1-\lambda_i) \tag{6.20}$$

$$\lambda_{max}(r, r+1) = -T\log(1-\lambda_{r+1}) \tag{6.21}$$

where λ_i are the estimated values of the characteristic roots (also called eigenvalues) obtained from the estimated π matrix and T is the number of usable observations. The first statistic tests the null hypothesis that the number of distinct co-integrating vectors is less than or equal to r against a general alternative. From the previous discussion, it should be clear that λ_{trace} equals zero when all $\lambda_i = 0$. The further the estimated characteristic roots are from zero, the larger the λ_{trace} statistic. The second statistic tests the null that the number of co-integrating vectors is r against the alternative of r + 1 co-integrating vectors. Again, if the estimated value of the characteristic root is close to zero, λ_{max} will be small.

The Johansen procedure allows for testing of restricted forms of the co-integrating vector(s). If there are r co-integrating vectors, only these r linear combinations of the variables are stationary. All other combinations are non-stationary. Thus, suppose the model is re-estimated restricting the parameters of π. If the restrictions are not binding, the number of co-integrating vectors should not have diminished. In order to test restrictions on the co-integrating vector, Johansen defines the two matrices α and β both of dimension $(n \times r)$ where r is the rank of π. The properties of α and β are such that:

$$\pi = \alpha\beta' \tag{6.22}$$

The matrix β is the matrix of co-integrating parameters and the matrix α is the matrix of weights with which each co-integrating vector enters the n equations of the VAR. In a sense α can be viewed as the matrix of speed of adjustment parameters. Due to the cross-equation restrictions, it is not possible to estimate α and β using OLS. Nevertheless, if you use maximum likelihood estimation it is possible to estimate the error-correction model, to determine the rank of π, to use the r most significant co-integrating vectors to form β' and to select α such that $\pi = \alpha\beta'$.[23]

6.3.2 Results

To determine the co-integrating relationships within the EMS interest rates both the Engle-Granger and the Johansen procedure were employed. First, the Engle-Granger method was used to examine the long-run relationship. Evidently, due to the large number of variables and thus the lack of critical values - Engle and Yoo (1987) only present critical values up to five variables - no clear outcome was achieved. After the first step of the Engle-Granger procedure it could be speculated that there were too many variables for this procedure to be efficient and hence the error correction models were in most cases not estimated. Due to the large number of possible solutions, the estimated error correction models, for all of the original as well as original and adjusted interest rates for the whole period, are not reported here. Bivariate Engle-Granger tests were performed for Germany and each of the other EMS interest rates to see, whether convergence had occurred between them.

[23] Based on Banerjee et al. (1993, 261 - 274), Enders (1996, 173 - 177) and Harris (1995, 76 - 95).

Following, the Johansen method was used to determine the number of co-integrating relationships. The German dominance hypothesis states that the EMS interest rates have converged to one level. Therefore, for complete convergence to hold there have to be exactly n - 1 co-integrating vectors within the n variables and thus one stochastic trend. Since there appeared to be more than one stochastic trend within each sample - thus indicating only partial convergence - the test was conducted for sub-sets of countries.

Although the Johansen procedure can detect differing orders of integration, both parts were primarily performed for the group of I(1) interest rates. This is in accordance with what was indicated earlier: for the variables to be co-integrated, they need to be integrated of the same order. Due to possible defaults in determining the order of integration the tests were conducted including all of the interest rates as well. The German, Belgian, Danish, French, Italian and Dutch interest rates will be treated as I(1) in the entire period and in the first sub-period, May 1987 - June 1997, where the Finnish and Spanish interest rates are as well considered I(1), while only the Irish adjusted interest rates are regarded as I(1) in this period. Since the results for the last period starting in August 1993 were deceptive, all of the interest rates in the group will be treated uniformly.

Before starting the co-integration analysis it was necessary to determine the lag length. To estimate the lag length two criteria were used, Akaike's Information Criterion (AIC) and the Schwarz's Bayesian Criteria (SBC). The criteria to be minimized are (Judge et al 1985, 687):

$$AIC(j) = \ln |\Sigma_j| + 2k^2 j / T, \tag{6.23}$$

$$SBC(j) = \ln |\Sigma_j| + k^2 j \ln T / T, \tag{6.24}$$

where $|\Sigma_j|$ is the determinant of the co-variance matrix, k is the number of variables, j the number of lags and T the number of observations. For the number of observations usually found with economic data, the Schwartz criterion favors a lower dimensional model than the Akaike criterion and as the sample size grows, the difference between the criteria grows (Judge et al. 1985, 873). Consequently, here as well the SBC is preferred over the AIC. The results from the tests including all interest rates are found in table 6.7.

Table 6.7 Selection of Lag Length

	2 lags		**4 lags**	
	AIC	SBC	AIC	SBC
Original 4/1979 - 6/1997	-1189,05	-730,64	-1305,23	-417,85
Adjusted 4/1979 - 6/1997	-728,43	-268,76	-766,80	123,05
Original 5/1987 - 6/1997	-1409,39	-932,73	-1488,72	-566,08
Adjusted 5/1987 - 6/1997	-1686,49	-1209,83	-1703,95	-781,31
Original 8/1993 - 6/1997	-1293,88	-984,94	*	

* The AIC and SBC were not available with 4 lags for 8/1993 - 6/1997.

Since the SBC is considered more reliable, two lags are selected for all periods. Concerning the Johansen test, which uses differenced data instead of undifferenced used in estimating the AIC and SBC, a lag length of one was used. However, due to large first-order auto-correlations in the error process, a lag length of two was later chosen for the Johansen test.

The results from the co-integration analysis are organized as follows: the results of both the Engle-Granger and Johansen tests are first presented for the entire period and then for the sub-periods. For the period starting in August 1993 only the Johansen procedure was employed, since, as stated earlier, the order of integration of the variables could not be positively defined. In general, the tables of the results for the I(1) variables are found here, whereas the results including the stationary variables as well are placed in the appendix.

6.3.2.1 April 1979 - June 1997

Engle-Granger Procedure

The long-run equilibrium regression was estimated setting each interest rate, in turn, on the left-hand side. The estimated long-run relationships are summarized (with *t*-values in parentheses) in table 6.8 for the original I(1) rates and in table 6.9 for the original German and Dutch and adjusted Belgian, Danish, French and Italian interest rates. The tables including the stationary Irish and Spanish rates can be found in the appendix (tables 7 and 8).

Table 6.8 Long-run Relationships: Original I(1) Data, 4/1979 - 6/1997.
Dependent variable on the vertical axis.

**	Constant	G	B	D	Fr	It	N
G	-0,508		-0,039	0,008	0,102	0,026	0,920*
	(-1,83)		(-0,72)	(0,13)	(1,71)	(0,67)	(17,38)
B	-2,472*	-0,062		0,376*	0,365*	0,249*	0,331*
	(-8,01)	(-0,72)		(5,21)	(5,11)	(5,39)	(3,27)
D	1,570*	0,010	0,300*		0,134*	-0,050	0,418*
	(5,32)	(0,13)	(5,21)		(2,00)	(-1,13)	(4,75)
Fr	-0,934*	0,132	0,299*	0,138*		0,401*	0,064
	(-2,99)	(1,71)	(5,11)	(2,00)		(11,40)	(0,68)
It	4,782*	0,080	0,481*	-0,121	0,945*		-0,654*
	(13,19)	(0,67)	(5,39)	(-1,13)	(11,40)		(-4,77)
N	1,012*	0,638*	0,144*	0,229*	0,034	-0,148*	
	(4,56)	(17,38)	(3,27)	(4,75)	(0,68)	(-4,77)	

* significant at the 5% level.
** G = Germany, B = Belgium, D = Denmark, Fr = France, It = Italy and N = Netherlands

Table 6.9 Long-run Relationships: Original (o) and Adjusted (a) I(1) Data, 4/1979 - 6/1997.
Dependent variable on the vertical axis.

**	Constant	G	B	D	Fr	It	N
G	-0,610*		-0,010	0,089	0,005	0,048	0,896*
	(-2,53)		(-0,24)	(1,93)	(0,09)	(1,36)	(17,73)
B	-1,386*	-0,027		0,278*	0,327*	0,094	0,540*
	(-3,56)	(-0,24)		(3,74)	(3,65)	(1,62)	(4,32)
D	1,086*	0,192	0,222*		0,157	0,033	0,220
	(3,09)	(1,93)	(3,74)		(1,91)	(0,63)	(1,90)
Fr	-1,300*	0,008	0,180*	0,107		0,484*	0,274*
	(-4,59)	(0,09)	(3,65)	(1,91)		(17,65)	(2,89)
It	4,145*	0,180	0,130	0,057	1,227*		-0,759*
	(10,97)	(1,36)	(1,62)	(0,63)	(17,65)		(-5,24)
N	1,128*	0,665*	0,149*	0,076	0,138*	-0,151*	
	(5,76)	(17,73)	(4,32)	(1,90)	(2,89)	(-5,24)	

* significant at the 5% level.
** G = Germany (o), B = Belgium (a), D = Denmark (a), Fr = France (a), It = Italy (a) and N = Netherlands (o)

Next, it was determined whether the residuals from the equilibrium regressions are stationary. This was done using the Dickey-Fuller statistic as well as the augmented Dickey-Fuller statistic. In the augmented Dickey-Fuller test one and four lagged first differences of the residual were used. Engle and Yoo provide the critical values for the *t*-statistic up to five variables (1987, 157). Since here six to eight variables were used, no critical values were available. As the critical value for five variables with a sample size of 200 at the 5% level is -4,48, the critical values are assumed to be approximately -4,80 and -5,40 for six and eight variables respectively. It should be noted that these values are only estimates. The results of the unit root tests for the entire period are presented in table 6.7 for the I(1) original rates and in table 6.8 for the other I(1) sample with original German and Dutch and adjusted Belgian, Danish, French and Italian interest rates. The tables with the results for all of the variables can be found in the appendix (tables 9 and 10).

Table 6.10 Unit Roots Tests for the Residuals: Original Data, 4/1979 - 6/1997

Country	DF	ADF(1)	ADF(4)
Germany	-3,803	-4,223	-3,596
Belgium	-4,405	-4,803	-4,081
Denmark	-3,435	-4,052	-3,557
France	-4,847*	-5,791*	-4,817*
Italy	-4,170	-5,295*	-4,454
Netherlands	-4,516	-5,565*	-4,837*

* the presence of a unit root is rejected at the 5% level.

Table 6.11 Unit Root Tests for the Residuals: Original (o) and Adjusted (a) I(1) Data, 4/1979 - 6/1997

Country	DF	ADF(1)	ADF(4)
Germany (o)	-4,030	-3,883	-3,346
Belgium (a)	-7,001*	-6,809*	-5,280*
Denmark (a)	-8,360*	-6,380*	-4,010
France (a)	-7,620*	-6,135*	-4,704
Italy (a)	-6,850*	-5,656*	-4,170
Netherlands (o)	-5,159*	-5,461*	-4,134

* the presence of a unit root is rejected at the 5% level.

It appears that in the first group the only residual that could be considered stationary with certainty is the one from the equilibrium equation of the French interest rate, whereas in the second group the only stationary residual is that of the adjusted Belgian rate. When all of the original interest rates are included, the residuals from the Irish and Spanish equilibrium equations, besides the French one, seem to reject the presence of a unit root, which is not surprising, since both interest rates are stationary. When the adjusted Irish and original Spanish rates are included among the group of original and adjusted interest rates, the residual for Belgium appears stationary, but considering the others no definite outcome can be stated.

Essentially, the Engle-Granger procedure is applied to examining bivariate co-integration. This is done here between Germany and each of the other EMS countries. To conserve space the long-term relationships are presented in the appendix (tables 11 and 12). The presence of a unit root in the residuals was examined using the Dickey-Fuller and the augmented Dickey-Fuller using four lagged differences of the dependent variable. Engle and Yoo report -3,37 as the critical value for two variables with a sample size of 200 (1987, 157). The results for the original and adjusted rates are found in table 6.12. The only stationary residuals seem to be found between Germany and the Netherlands. Thus, independent of the choice of the left-hand side variable, the German and Dutch interest rates are considered co-integrated, CI(1,1).

Table 6.12 Unit Root Tests for the Residuals: Bivariate Relationships, 4/1979 - 6/1997. Germany used as a regressor / regressed.

Country		DF	ADF(4)
Belgium	**(o)**	-1,976 / -1,965	-1,518 / -1,715
	(a)	-4,977* / 4,163*	-2,996 / -2,585
Denmark	**(o)**	-2,484 / -2,647	-2,336 / -2,675
	(a)	-7,067* / -5,859*	-2,917 / -2,881
France	**(o)**	-1,996 / -2,001	-1,559 / -1,799
	(a)	-3,074 / -2,634	-1,541 / -1,817
Italy	**(o)**	-1,353 / -1,456	-1,385 / -1,703
	(a)	-1,976 / -1,669	-1,405 / -1,727
Netherlands	**(o)**	-3,903* / -3,797*	-3,766* / -3,600*

* the presence of a unit root is rejected (critical value -3,37).

The results from the Engle-Granger procedure suggest that there are co-integrating relationships between the EMS interest rates. Yet, it can not be said with certainty what these relationships are. Next the co-integration of the EMS interest rates is examined with the Johansen procedure to see if the results from this section can be clarified.

Johansen Procedure

The results of the Johansen test for the entire period I(1) rates can be seen in table 6.13 for the original and in table 6.14 for the credibility adjusted rates. The statistics including the I(0) variables, Ireland and Spain, are found in the appendix (tables 17 and 18). The critical values have been taken from Banerjee et al. (1996, 274). Whereas four co-integrating vectors exist within all of the original, only three are found from the group of the I(1) interest rates. The same amount of co-integrating vectors are found among the original German and Dutch and the adjusted Belgian, Danish, French and Italian interest rates. When the stationary interest rates, the adjusted Irish and the original Spanish rate, are added the number of co-integrating vectors rises to five. This is in accordance with the I(1) results, since two stationary relationships are added.

Table 6.13 Tests of Co-integration Rank: Original I(1) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	6	0,289	73,96*	39,37	159,81*	94,15
1	5	0,153	36,16*	33,46	85,84*	68,52
2	4	0,126	29,29*	27,07	49,69*	47,21
3	3	0,061	13,60	20,97	20,40	29,68
4	2	0,022	4,83	14,07	6,80	15,41
5	1	0,009	1,97	3,76	1,97	3,76

* rejection at the 5% level.

Table 6.14 Tests of Co-integration Rank: Original and Adjusted I(1) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	6	0,240	59,51*	39,37	172,13*	94,15
1	5	0,203	49,34*	33,46	112,63*	68,52
2	4	0,159	37,54*	27,07	63,28*	47,21
3	3	0,075	16,95	20,97	25,74	29,68
4	2	0,033	7,27	14,07	8,79	15,41
5	1	0,007	1,52	3,76	1,52	3,76

* rejection at the 5% level.

The presence of three co-integrating vectors among the six interest rates indicates three stochastic trends in the data set. As indicated earlier, complete convergence of the interest rates requires that n - 1 co-integrating vectors, and thus one unique stochastic trend, are found among a group of n interest rates. The existence of three stochastic trends within the six EMS interest rates implies the rejection of the complete convergence hypothesis. Nevertheless, it appears that some interest rates may have converged. Following, the sub-sets of the countries are examined to find out where possible convergence might have occurred.

The number of co-integrating vectors found between the sub-sets of countries are summarized in table 6.15 for the original rates and table 6.16 for the original German and Dutch and adjusted Belgian, Danish, French and Italian interest rates. The tables presenting the statistics behind these numbers can be found in the appendix (tables 20 - 34 for the original rates and 35 - 48 for the adjusted ones). The purpose is to see if clearly three groups of countries emerge as was indicated by the test for the whole group.

Table 6.15 Number of Co-integrating Vectors: Original I(1) Data, 4/1979 - 6/1997

Countries*	λ_{max}	λ_{trace}
G - B - D - Fr - N	2	2
G - B - D - Fr	1	1
G - B - D - N	1	1
G - B - D	0	0
G - N	1	1
B - D - Fr - It - N	3	3
B - D - Fr - It	2	2
B - D - Fr - N	2	2
B - D - Fr	1	1
B - D - It	1	1
B - D - N	1	1
B - Fr - It	2	2
D - Fr - It	1	1
D - Fr - N	1	1

* G = Germany, B = Belgium, D = Denmark, Fr = France, It = Italy and N = Netherlands

Table 6.16 Number of Co-integrating Vectors: Original (o) and Adjusted (a) I(1) Data, 4/1979 - 6/1997

Countries*	λ_{max}	λ_{trace}
G - B - D - Fr - N	2	2
G - B - D - Fr	2	2
G - B - D - N	2	2
G - B - D	2	2
G - N	1	1
G - B - Fr - N	1	1
B - D - Fr - It - N	3	3
B - D - Fr - It	2	2
B - D - Fr - N	2	2
B - D - Fr	2	2
B - D - It	1	1
B - D - N	2	2
B - Fr - It	2	2
D - Fr - It	1	1
D - Fr - N	1	1

* G = Germany (o), B = Belgium (a), D = Denmark (a), Fr = France (a), It = Italy (a) and N = Netherlands (o)

Two groups of five interest rates were separated: one without Italy to see if the others form a tight group due to the closeness of the economies and an another without Germany to see if Germany has a significant part in forming the co-integrating relation. Removing Italy reduces the number of co-integrating vectors to two, leaving the number of stochastic trends unchanged at three. There are three co-integrating vectors in the group without Germany, but only two stochastic trends. The five other original - Belgian, Danish, French, Italian and Dutch - interest rates seem to have converged more with each other than with Germany. One stochastic trend is found between Belgium, France and Italy. As expected a unique co-integrating vector, and thus one stochastic trend, is found between Germany and the Netherlands.

Excluding Germany from the group of original Dutch and adjusted Belgian, Danish, French and Italian interest rates also produces two stochastic trends, but adjusting for credibility brings some changes to the co-integrating relationships within this group. There is now one stochastic trend between Germany, Belgium and Denmark, Belgium, Denmark and France as well as Belgium, Denmark and the Netherlands besides the one between Belgium, France and Italy that was already observed in the original group. The credible interest rate have been more convergent with the German and Dutch rates, which would suggest that the fundamentals of the interest rates have followed the strong economies.

6.3.2.2 May 1987 - June 1997

Engle-Granger Procedure

The results of the estimation of the long-run relationship are presented in table 6.17 for the I(1) original interest rates and 6.18 for all of the adjusted ones. The table comprising all of the original rates can be found in the appendix (table 13).

Table 6.17 The Long-run Relationships: Original I(1) Data, 5/1987 - 6/1997.
Dependent variable on the vertical axis.

**	Const.	G	B	D	Fi	Fr	It	N	S
G	-0,167		0,140*	-0,001	-0,069*	0,027	0,105*	0,981*	-0,118*
	(-0,66)		(2,80)	(-0,03)	(-2,79)	(0,51)	(3,05)	(27,37)	(-6,14)
B	2,180*	0,460*		0,107*	0,244*	0,268*	-0,321*	-0,066	0,061
	(5,31)	(2,80)		(2,03)	(5,91)	(2,85)	(-5,58)	(-0,37)	(1,52)
D	-1,601*	-0,010	0,324*		-0,199*	0,890*	0,036	-0,016	0,197
	(-2,05)	(-0,03)	(2,03)		(-2,49)	(6,06)	(0,32)	(-0,05)	(2,93)
Fi	-6,559*	-0,892*	0,963*	-0,260*		0,273	0,731*	0,913*	0,078
	(-9,75)	(-2,73)	(5,91)	(-2,49)		(1,43)	(6,69)	(2,65)	(0,98)
Fr	-0,544	0,083	0,249*	0,274*	0,064		0,218*	-0,007	0,077*
	(-1,24)	(0,51)	(2,85)	(6,06)	(1,43)		(3,69)	(-0,04)	(2,04)
It	5,785*	0,719*	-0,668*	0,025	0,385*	0,450*		-0,541*	0,097
	(15,26)	(3,05)	(-5,58)	(0,32)	(6,69)	(3,69)		(-2,14)	(1,69)
N	0,056	0,885*	-0,018	-0,001	0,063*	-0,002	-0,071*		0,082*
	(0,23)	(27,37)	(0,37)	(0,05)	(2,65)	(-0,04)	(-2,14)		(4,21)
S	2,017	-2,109*	0,330	0,356*	0,107	0,453*	0,253	1,634*	
	(1,92)	(-6,14)	(1,52)	(2,93)	(0,98)	(2,04)	(1,69)	(4,219	

* significant at the 5% level.
** G = Germany, B = Belgium, D = Denmark, Fi = Finland, Fr = France, Ir = Ireland, It = Italy, N = Netherlands and S = Spain

Table 6.18 The Long-run Relationships: Original (o) and Adjusted (a) Data, 5/1987 - 6/1997.
Dependent variable on the vertical axis.

**	Const.	G	B	D	Fi	Fr	Ir	It	N	S
G	-0,030		0,138*	-0,126*	-0,048	0,104*	-0,052	0,089*	1,029*	-0,083*
	(-0,13)		(3,04)	(-3,78)	(-1,95)	(2,43)	(-1,61)	(2,83)	(27,36)	(-4,26)
B	1,999*	0,549*		0,274*	0,253*	0,049	-0,079	-0,262*	-0,137	0,091*
	(4,51)	(3,04)		(4,17)	(5,73)	(0,56)	(-1,23)	(-4,34)	(-0,66)	(2,21)
D	-0,716	-0,889*	0,485*		-0,177*	0,630*	0,080	0,078	0,912*	0,040
	(-1,12)	(-3,78)	(4,17)		(-2,73)	(6,26)	(0,93)	(0,91)	(3,49)	(0,72)
Fi	-6,516*	-0,676	0,889*	-0,350*		0,209	0,522*	0,651*	0,602	-0,013
	(-9,85)	(1,95)	(5,73)	(-2,73)		(1,28)	(4,67)	(6,17)	(1,57)	(-0,16)
Fr	-0,775	0,476*	0,057	0,409*	0,068		-0,043	0,190*	-0,316	0,129*
	(-1,52)	(2,43)	(0,56)	(6,26)	(1,28)		(-0,62)	(2,82)	(-1,44)	(2,97)
Ir	2,183*	-0,431	-0,166	0,094	0,310*	-0,078		-0,069	0,851*	0,190*
	(3,29)	(-1,61)	(-1,23)	(0,93)	(4,67)	(-0,62)		(-0,74)	(2,95)	(3,29)
It	5,957*	0,742*	-0,546*	0,092	0,387*	0,346*	-0,069		-0,631*	0,139*
	(14,49)	(2,83)	(-4,34)	(0,91)	(6,17)	(2,82)	(-0,74)		(-2,15)	(2,34)
N	-0,080	0,845*	-0,028	0,106*	0,035	-0,057	0,084*	-0,062*		0,039*
	(-0,37)	(27,36)	(-0,664)	(3,49)	(1,57)	(-1,44)	(2,95)	(-2,15)		(2,09)
S	0,418	-1,663*	0,456*	0,114	-0,018	0,563*	0,458*	0,334*	0,953*	
	(0,39)	(-4,26)	(2,21)	(0,72)	(-0,16)	(2,97)	(3,29)	(2,34)	(2,09)	

* significant at the 5% level.
** G = Germany, B = Belgium, D = Denmark, Fi = Finland, Fr = France, Ir = Ireland, It = Italy, N = Netherlands and S = Spain

Next, the Dickey-Fuller and augmented Dickey-Fuller with one and four lags are conducted on the residuals of the equilibrium equations to see whether they are stationary or not. As was noted earlier, when the tests were conducted for the whole period rates, critical values in Engle and Yoo (1987, 157) are only available for five variables. The critical values for eight and nine variables respectively are approximately -5,4 and -5,7. Tables 6.19 and 6.20 present the results for the original I(1) interest rates and for the adjusted rates. The results for the original rates, including the Irish rate, are found in the appendix (table 14). None of the residuals of the original rates clearly rejects the presence of a unit root, whereas within the group of the adjusted rates the residuals of the Finnish and French rates could be interpreted as stationary.

Table 6.19 Unit Root Tests on the Residuals: Original I(1) Data, 5/1987 - 6/1997

Country	D-F	ADF(1)	ADF(4)
Germany	-3,963	-4,665	-3,761
Belgium	-5,040	-4,922	-3,104
Denmark	-7,646*	-5,016	-3,689
Finland	-4,568	-5,051	-2,654
France	-5,487*	-4,788	-4,633
Italy	-4,628	-4,807	-4,054
Netherlands	-3,491	-4,016	-3,303
Spain	-4,173	-3,819	-4,036

* approximated significant at the 5% level.

Table 6.20 Unit Root Tests on the Residuals: Original (o) and Adjusted (a) Data, 5/1987 - 6/1997

Country	D-F	ADF(1)	ADF(4)
Germany	-4,504	-4,217	-3,452
Belgium	-5,209	-4,642	-3,449
Denmark	-5,875	-4,207	-2,918
Finland	-6,032*	-5,922*	-3,637
France	-6,982*	-5,759*	-4,803
Ireland	-6,079*	-4,220	-2,827
Italy	-8,018*	-5,465	-4,200
Netherlands	-3,887	-3,633	-3,342
Spain	-4,693	-3,778	-4,536

* approximated significant at the 5% level.

Bivariate causality is again examined between Germany and each of the other EMS countries. The long-term relationships can be found in the appendix (tables 15 and 16). The presence of a unit root in the residuals was determined using the Dickey-Fuller and the augmented Dickey-Fuller with four lagged differences of the dependent variable. The critical value for two variables with a sample size of 100 is -3,37 (Engle and Yoo 1987, 157). The results for the original and adjusted rates are found in table 6.21. The results resemble those for the whole period: the only definite co-integrating relation is found between Germany and the Netherlands.

Table 6.21 Unit Root Tests for the Residuals: Bivariate Relationships, 5/1987 - 6/1997. Germany used as a regressor / regressed.

Country		DF	ADF(4)
Belgium	**(o)**	-2,430 / -2,593	-1,800 / -2,141
	(a)	-2,903 / -2,930	-1,967 / -2,262
Denmark	**(o)**	-3,825* / -3,134	-2,313 / -2,348
	(a)	-3,486* / -3,179	-2,830 / -2,877
Finland	**(o)**	-2,033 / -2,186	-1,680 / -1,939
France	**(o)**	-2,278 / -2,436	-1,753 / -2,120
	(a)	-3,229 / -3,048	-2,306 / -2,425
Italy	**(o)**	-2,199 / -1,981	-2,781 / -2,329
	(a)	-4,001* / -2,997	-2,607 / -2,209
Netherlands	**(o)**	-3,625* / -3,715*	-4,075* / -4,288*
Spain	**(o)**	-2,437 / -3,731*	-2,120 / -2,490

* the presence of a unit root is rejected (critical value -3,37).

According to the Engle-Granger procedure there were less co-integrating relationships in the period May 1987 - June 1997 than in the whole period. As indicated earlier, the hypothesis of the convergence of the EMS interest rates can not be resolved with this analysis, thus the Johansen procedure is conducted for these interest rates as well.

Johansen Procedure

The results from testing the co-integration rank for the sub-period are presented in table 6.22 for the original I(1) rates and in table 6.23 for the adjusted rates, which are all I(1). The statistics comprising all of the original rates, thus including Ireland, can be found in the appendix (table 19). Within all of the original rates five co-integrating vectors are found, which is reduced to four when the stationary Irish interest rate is excluded. The λ_{max} suggests three co-integrating vectors, but for example Harris recommends the λ_{trace} statistic (1995, 89). Among the data set including the original German, Finnish, Dutch and Spanish and adjusted Belgian, Danish, French, Irish and Italian interest rates four co-integrating vectors are again found, whereas the λ_{max} suggests that only two were present.

Table 6.22 Tests of Co-integration Rank: Original I(1) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	8	0,405	62,23*	51,42	225,12*	156,00
1	7	0,336	49,07*	45,28	162,89*	124,24
2	6	0,307	44,03*	39,37	113,82*	94,15
3	5	0,220	29,84	33,46	69,79*	68,52
4	4	0,142	18,39	27,07	39,94	47,21
5	3	0,107	13,58	20,97	21,56	29,68
6	2	0,063	7,80	14,07	7,97	15,41
7	1	0,001	0,17	3,76	0,17	3,76

* rejection at the 5% level.

Table 6.23 Tests of Co-integration Rank: Original and Adjusted I(1) Data, 5/1987 - 6/1997.

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	9	0,429	67,17*	57,12	251,86*	192,89
1	8	0,369	55,23*	51,42	184,69*	156,00
2	7	0,250	34,59	45,28	129,46*	124,24
3	6	0,248	34,19	39,37	94,87*	94,15
4	5	0,164	21,53	33,46	60,67	68,52
5	4	0,147	19,07	27,07	39,15	47,21
6	3	0,101	12,76	20,97	20,08	29,68
7	2	0,059	7,25	14,07	7,32	15,41
8	1	0,001	0,07	3,76	0,07	3,76

* rejection at the 5% level.

The presence of four co-integrating vectors within eight interest rates, indicates four stochastic trends among the original rates, whereas five trends were found after the Belgian, Danish, French and Italian interest rates were adjusted for poor credibility. Thus, the hypothesis of complete convergence within the EMS interest rates can be rejected for the later period as well and it seems that there is more convergence among the interest rates, when the entire period is considered. Next, the sub-sets of countries are examined to see which of the interest rates may indeed have converged.

The results are summarized in table 6.24 for the original rates excluding the Irish rate and in table 6.25 for the original German, Finnish, Dutch and Spanish and adjusted Belgian, Danish, French, Irish and Italian rates. As earlier, the statistics behind the numbers can be found in the appendix (tables 49 - 67 for the original rates and 68 - 85 for the credibility adjusted ones).

Table 6.24 Number of Co-integrating Vectors: Original I(1) Data, 5/1987 - 6/1997

Countries*	λ_{max}	λ_{trace}
G - B - D - Fr - N	0	1
G - B - D - Fr	1	1
G - B - D - N	0	1
G - B - D	0	0
G - Fi - It - N - S	3	2
G - Fi - N	2	2
B - D - Fi - Fr - It - N - S	3	3
B - D - Fr - It - N	2	1
B - D - Fr - It - S	2	2
B - D - Fr - It	2	2
B - D - Fr - N	1	1
B - D - Fr	0	1
B - D - It	1	1
B - D - N	1	0
B - Fr - It	1	1
B - Fr - N	1	1
Fr - It - S	2	2

* Germany (G), Belgium (B), Denmark (D), Finland (Fi), France (Fr), Italy (It), the Netherlands (N) and Spain (S)

Table 6.25 Number of Co-integrating Vectors: Original and Adjusted I(1) Data, 5/1987 - 6/1997

Countries*	λ_{max}	λ_{trace}
G - B - D - Fr - N	0	1
G - B - D - Fr	1	1
G - B - D - N	0	0
G - B - D	0	0
G - Fi - N	2	2
B - D - Fi - Fr - Ir - It - N - S	2	2
B - D - Fr - It	1	1
B - D - Fr - N	0	1
B - D - Fr	1	1
B - D - Ir - It - S	1	2
B - D - It	0	0
B - D - N	0	0
B - Fr - N	0	0
D - Fr - It	2	1
D - Fr - N	1	1
Fr - It - S	2	2

* Germany (G), Belgium (B), Denmark (D), Finland (Fi), France (Fr), Ireland (Ir), Italy (It), the Netherlands (N) and Spain (S)

When Germany is excluded from the group of original I(1) interest rates, the number of co-integrating vectors is reduced to three, while four stochastic trends remain. In the group of the adjusted rates, the same procedure increases the number of stochastic trends to six from five, while there are two co-integrating vectors compared with four when Germany was included. This would suggest that the group of adjusted rates has converged less than that of the original ones. Considering the original rates one stochastic trend is found between Germany, Finland and the Netherlands on the one hand and between France, Italy and Spain on the other. These groups remain after the credibility adjustment and besides there appears to be one stochastic trend between the Danish, French and Italian rates (based on the λ_{max}). The unique stochastic trends that appeared between Germany, Belgium and Denmark on one hand and between Belgium, Denmark and the Netherlands on the other seem to have disappeared in this period - three stochastic trends are now found in these groups.

6.3.2.3 August 1993 - June 1997

Since no clear answer was received as to regard the orders of integration within this group, only the Johansen test was employed here. The results for the number of co-integrating vectors within these nine interest rates are presented in table 6.26. λ_{max} statistic shows signs of possible bias in the test, but the λ_{trace} indicates that seven co-integrating vectors were present among the nine interest rates and thus two stochastic trends. This suggests that the interest rates have converged after 1993. Notice should be taken however that due to the mixed orders of integration, the results may be biased.

Table 6.26 Tests of Co-integration Rank, 8/1993 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	9	0,904	105,31*	57,12	347,80*	192,89
1	8	0,742	60,97*	51,42	242,49*	156,00
2	7	0,712	55,98*	45,28	181,52*	124,24
3	6	0,528	33,82	39,37	125,53*	94,15
4	5	0,488	30,10	33,46	91,71*	68,52
5	4	0,418	24,37	27,07	61,60*	47,21
6	3	0,404	23,26*	20,97	37,22*	29,68
7	2	0,252	13,08	14,07	13,97	15,41
8	1	0,020	0,90	3,76	0,90	3,76

* rejection at the 5% level.

6.4 Granger Causality Tests

Co-integration procedures state the possible convergence of interest rates but nothing can be said of the cause of this convergence, i.e. who determines the monetary policy in these groups of converging interest rates. Granger causality tests have been widely used to reveal the causal relations in the EMS. To begin with the concept of Granger causality is discussed, which is followed by the results from this last test.

6.4.1 Methodology

To observe the causal relations between the EMS countries the so-called Granger causality tests (1969) are used. To put it simply, the Granger test utilizes the F-statistic to examine whether lagged values of X contribute significantly to the explanation of Y_t, once lagged values of Y have been incorporated; if they do, X is said to ”Granger-cause” Y. Similarly, to examine whether Y ”causes” X, the contribution of lagged values of Y to the explanation of X is examined (having already accommodated the contribution of lagged X to its own explanation). The test, thus, consists of running regressions of Y on itself lagged and on a set of lagged X values; if the lagged values of X do not contribute a statistically significant explanation regression of X on itself lagged and a set of lagged Y values is run and the contribution of the lagged Y values is examined by an F-test. Two regressions are run:

$$Y_t = \Sigma_{j=1}^{k} (\theta_j Y_{t-j} + \beta_j X_{t-j}) + \varepsilon_t \tag{6.25}$$

$$X_t = \Sigma_{j=1}^{k} (\lambda_j X_{t-j} + \alpha_j Y_{t-j}) + \upsilon_t \tag{6.26}$$

and the hypothesis H_{0X}: $\beta_j = 0$ for all j is tested in the first equation, and H_{0Y}: $\alpha_j = 0$ for all j is tested in the second equation. If the former is not rejected then X does not Granger-cause Y and if the latter is not rejected then Y does not Granger-cause X. There are no obvious routes by which to determine the lag length, k.

Several outcomes are possible. Neither X nor Y Granger-cause each other, both X and Y Granger-cause each other, so that there is bi-directional causality, X Granger-cause Y but Y does not Granger-cause X or Y Granger-causes X but X does not Granger-cause Y.

Granger causality tests only observe how the past values of one variable affect the present value of another variable. Here the contemporaneous value of X plays no role in the first regression, and similarly the contemporaneous value of Y plays no role in the second regression. Hence, the so called tequila effect may be observable here. According to Eichengreen et al. (1996) currency crises can be contagious, i.e. a speculative attack in one country increases the probability of a speculative attack in another country. This argumentation has been initiated especially by the Mexican peso crisis, where the Mexican crisis caused weakening exchange rates in for example Argentina, which justified multilateral intervention by the IMF among others. Thus, the causal relations between two countries could be explained with a crisis that occurred first in one country and then spilled contagiously to another country.[24]

6.4.2 Results

For German dominance to hold, the German rate should Granger-cause the other EMS rates, but not be affected by them. The omitted variables test, used earlier in the de Grauwe tests, is similar to the Granger causality test. Since trivariate causality was examined there, taking into account the influence of the US interest rates, only bivariate causality is considered in this section. As noted earlier there are no obvious routes for determining the lag length. Here a lag length of 8 is used. The results are again divided after the period in question.

April 1979 - June 1997

The results for the whole period, April 1979 - June 1997, are presented in table 6.27 for the original rates and table 6.28 for the credibility adjusted rates. When the original rates are analyzed Germany is significant in explaining the interest rates of Belgium, Denmark, France and the Netherlands, whereas it has no effect on Ireland, Italy and Spain. These causal relations involving Germany remain unchanged with the adjusted rates, whereas several changes can be observed with the other causal relationships. Notice should be given to all results involving the Irish and Spanish rates. Due to the stationarity of these interest rates, the use of first differences may have caused some bias in the results.

[24] Based on Darnell (1994, 41 - 43).

Table 6.27 Granger Causality Tests: Original Data, 4/1979 - 6/1997.
Dependent variable is on the vertical axis.

	G	B	D	Fr	Ir	It	N	S
G		0,767 (0,63)	0,972 (0,46)	1,089 (0,37)	1,183 (0,31)	0,225 (0,99)	1,305 (0,24)	0,736 (0,66)
B	4,608** (0,00)		2,383* (0,02)	2,688** (0,01)	3,165** (0,00)	0,797 (0,61)	2,579** (0,01)	2,452* (0,02)
D	2,269* (0,02)	1,735 (0,09)		1,881 (0,06)	8,817** (0,00)	2,485** (0,01)	5,152** (0,00)	2,408* (0,02)
Fr	9,909** (0,00)	1,693 (0,10)	1,793 (0,08)		4,073** (0,00)	1,222 (0,29)	3,387** (0,00)	0,840 (0,57)
Ir	0,752 (0,65)	0,633 (0,75)	0,333 (0,95)	2,686** (0,01)		12,772** (0,00)	0,597 (0,78)	0,378 (0,93)
It	1,579 (0,13)	1,117 (0,35)	0,621 (0,76)	0,985 (0,45)	0,848 (0,56)		1,618 (0,12)	0,315 (0,96)
N	6,511** (0,00)	2,813** (0,01)	1,241 (0,28)	3,774** (0,00)	0,825 (0,58)	0,864 (0,55)		1,828 (0,07)
S	1,143 (0,34)	1,030 (0,41)	1,838 (0,07)	2,371* (0,02)	1,257 (0,27)	1,361 (0,22)	3,610** (0,00)	

* significant at the 5% level; ** significant at the 1% level.
G = Germany, B = Belgium, D = Denmark, Fr = France, Ir = Ireland, It = Italy, N = Netherlands and S = Spain

Table 6.28 Granger Causality Tests: Original (o) and Adjusted (a) Data, 4/1979 - 6/1997.
Dependent variable is on the vertical axis.

	G	B	D	Fr	Ir	It	N	S
G		0,592 (0,78)	1,194 (0,30)	1,578 (0,13)	0,163 (1,00)	0,463 (0,88)	1,305 (0,24)	0,736 (0,66)
B	4,331** (0,00)		1,843 (0,07)	1,440 (0,18)	1,336 (0,23)	0,575 (0,80)	3,821** (0,00)	2,197* (0,03)
D	1,960* (0,05)	2,145* (0,03)		1,774 (0,08)	1,491 (0,16)	1,912 (0,06)	3,854** (0,00)	1,114 (0,36)
Fr	3,566** (0,00)	0,862 (0,55)	0,943 (0,48)		0,611 (0,78)	1,524 (0,15)	3,117** (0,00)	0,881 (0,53)
Ir	1,416 (0,19)	1,136 (0,34)	2,908** (0,00)	1,628 (0,12)		1,233 (0,28)	3,528** (0,00)	3,981** (0,00)
It	1,332 (0,23)	0,813 (0,59)	0,659 (0,73)	1,092 (0,37)	0,516 (0,84)		1,482 (0,17)	0,271 (0,97)
N	6,511** (0,00)	1,562 (0,14)	3,715** (0,00)	1,333 (0,23)	1,805 (0,08)	0,677 (0,71)		1,828 (0,07)
S	1,143 (0,34)	2,175* (0,03)	1,810 (0,08)	1,685 (0,10)	3,697** (0,00)	1,331 (0,23)	3,610** (0,00)	

* significant at the 5% level; ** significant at the 1% level.
G = Germany (o), B = Belgium (a), D = Denmark (a), Fr = France (a), Ir = Ireland (a), It = Italy (a), N = Netherlands (o) and S = Spain (o)

Whereas the original Belgian rate is affected in addition to Germany by Denmark, France, Ireland and Spain and has a two-way causal relationship with the Netherlands, the adjusted rate only reacts to the German and Dutch interest rates and has interaction with Spain. This indicates that the Belgian rate has moved with the other interest rates in the system, which may have forced the interest rate out of the rate-of-return band. When the credibility effect is removed the movement of the Belgian interest rate is dependent of Germany and the Netherlands. Poor credibility has caused the Belgian interest rate to follow the other poor credibility interest rates, whereas the fundamentals of the interest rates followed the strong economies of the EMS, Germany and the Netherlands.

Denmark shows similar results as Belgium. The original rates were affected by Germany, Ireland, Italy, the Netherlands and Spain, while removing the credibility effect revealed Germany and Belgium (the adjusted rate) as the determinants of the Danish interest rates as well as a two-way causal relationship between the Netherlands and Denmark. The explanation is to some extent the same as for Belgium, which can maybe be adhered to the size of both countries. The non-credible Danish interest rate moved with the other interest rates given the same status, while the credible interest rate followed the German and the credibility adjusted Belgian rate and had interaction with the Netherlands. The presence of the Belgian rate is best explained by the role that Germany and the Netherlands had in explaining the Belgian rate. Therefore, the importance of the Dutch rate for the Danish rate might be more important than is visible here.

Germany is the sole Granger-causal variable for the original France interest rate with interaction between France and Ireland as well as the Netherlands. The credibility of the French interest rate was clearly better than that of Belgium and Denmark, which might explain this result. The adjusted rate reveals the Netherlands besides Germany as significant in determining the French interest rate. The interaction with Ireland has disappeared with poor credibility. This indicates that France has indeed moved towards the hard currency block of Germany and the Netherlands, which may have helped improve the credibility record.

The Irish interest rate shows no signs of German influences, which contradicts Weber's suggestion that Ireland at least to some extent belonged to the hard currency block of Germany and the Netherlands. The markets view the original Irish interest rate as a follower of the Italian interest rate and as stated in the previous section there is some interaction with the French interest rate. The credible rate appears to be determined by Denmark and the Netherlands and interaction here is with the Spanish rate. Thus, the Irish interest rate is independent of Germany, but influenced by rates that are dependent on Germany. As noted above due to the stationarity of the Irish interest rate, the use of first differences may have caused some bias in the results.

The Italian interest rate is completely insulated from any influences from the other EMS economies. The Italian interest rate was outside the rate-of-return band only during two months before the exit from the system, therefore both rates show the same outcome. Capital controls together with the wider fluctuation band sheltered the Italian economy until 1990 and after September 1992 the same was done by the postponement of participation in the ERM. Hence, the Italian interest rate has followed its own path.

The close connection between Germany and the Netherlands is again visible. The Dutch interest rate is caused by Germany. Two-way causality is observed between the Dutch and the original Belgian and French interest rates and the credibility adjusted Danish interest rate.

The Spanish interest rate is independent of Germany as well as the Irish and Italian rates, but the Netherlands appear determinant. The original French interest rate is significant in explaining the Spanish rate as well, whereas there is interaction between the Spanish and the credibility adjusted Belgian and Irish rates. In addition to Spain being a late joiner in the EMS, it also used the wider fluctuation band, which may have helped it to remain its independence. As with Ireland some caution should be given to the possible bias caused by the use of first differences with a stationary series.

It appears that removing poor credibility from the Belgian, Danish and French interest rates diminishes the number of determinants and shifts the dependence towards the stronger economies of Germany and the Netherlands, whereas Italy has not affected any of the adjusted rates. The Italian interest rate, which could be considered to position at the other end of the spectrum, would seem to be insulated from influences from the other interest rates. Due to the stationarity of the Irish and Spanish interest rates no conclusions can be drawn considering these interest rates. The results here tend to support the outcome from the Johansen test, which was interpreted as convergence of the credibility adjusted rates with the stronger economies.

May 1987 - June 1997

The results of the causality tests for the second period are presented in table 6.29 for the original interest rates and 6.30 for the credibility adjusted ones. This period divides on both sides of the 1992 crisis, therefore the results reflect the situation before and after the crisis, which are in some respects opposite, i.e. the tight exchange rate constraint before the crisis with no realignments and the loose constraint of the wider fluctuation bands after August 1993. This may have caused some ambiguity to the outcome from this period. The original Irish interest rate appears to be significant in determining the German interest rate, but this disappears with the adjusted Irish rate. Since the original Irish interest rate is stationary, this result could be ignored, in contrast to the result with the adjusted rate that is I(1) as the other rates. Accordingly, some caution should be placed on the results achieved with the original Irish rate.

Table 6.29 Granger Causality Tests: Original Data, 5/1987 - 6/1997.
The dependent variable is on the vertical axis.

	G	B	D	Fi	Fr	Ir	It	N	S
G		0,114	1,656	0,877	1,995	2,356*	0,834	0,609	1,674
		(1,00)	(0,12)	(0,54)	(0,06)	(0,02)	(0,57)	(0,77)	(0,11)
B	1,701		2,932**	1,282	2,198*	8,412**	1,617	1,157	0,875
	(0,11)		(0,01)	(0,26)	(0,03)	(0,00)	(0,13)	(0,33)	(0,54)
D	2,964**	1,316		2,215*	3,537**	36,042**	3,836**	1,841	5,712**
	(0,01)	(0,24)		(0,03)	(0,00)	(0,00)	(0,00)	(0,08)	(0,00)
Fi	2,546**	1,027	0,517		0,906	1,648	1,276	2,823**	1,006
	(0,01)	(0,42)	(0,84)		(0,52)	(0,12)	(0,26)	(0,01)	(0,44)
Fr	2,577	0,953	2,694**	2,991**		3,974**	3,128**	2,361*	1,524
	(0,01)**	(0,48)	(0,01)	(0,00)		(0,00)	(0,00)	(0,02)	(0,16)
Ir	1,458	1,268	14,830**	5,740**	4,357**		14,816**	1,168	2,747**
	(0,18)	(0,27)	(0,00)	(0,00)	(0,00)		(0,00)	(0,33)	(0,01)
It	1,530	0,861	0,252	4,265**	0,347	0,520		1,951	1,169
	(0,16)	(0,55)	(0,98)	(0,00)	(0,95)	(0,84)		(0,06)	(0,33)
N	3,074**	0,531	1,174	2,836**	0,840	0,959	1,392		0,696
	(0,00)	(0,83)	(0,32)	(0,01)	(0,57)	(0,47)	(0,21)		(0,69)
S	2,726**	1,275	4,644**	2,546**	3,434**	10,342**	2,497*	1,776	
	(0,01)	(0,27)	(0,00)	(0,01)	(0,00)	(0,00)	(0,02)	(0,09)	

* significant at the 5% level; ** significant at the 1% level.
G = Germany, B = Belgium, D = Denmark, F = Finland, Fr = France, Ir = Ireland, It = Italy, N = Netherlands and S = Spain

Table 6.30 Granger Causality Tests: Original (o) and Adjusted (a) Data, 5/1987 - 6/1997. Dependent variable is on the vertical axis.

	G	B	D	Fi	Fr	Ir	It	N	S
G		0,360	1,810	0,877	0,481	1,222	1,389	0,609	1,674
		(0,94)	(0,08)	(0,54)	(0,87)	(0,29)	(0,21)	(0,77)	(0,11)
B	2,319*		2,650**	1,210	3,114**	0,675	1,010	1,668	0,583
	(0,03)		(0,01)	(0,30)	(0,00)	(0,71)	(0,43)	(0,12)	(0,79)
D	1,477	1,357		3,561	1,716	3,409**	5,847**	2,196*	0,900
	(0,18)	(0,23)		(0,00)	(0,10)	(0,00)	(0,00)	(0,03)	(0,52)
Fi	2,546**	1,508	1,324		0,991	0,655	3,853**	2,823**	1,006
	(0,01)	(0,16)	(0,24)		(0,45)	(0,73)	(0,00)	(0,01)	(0,44)
Fr	2,991**	1,217	1,133	2,210*		1,475	2,423*	2,457*	2,029*
	(0,00)	(0,30)	(0,35)	(0,03)		(0,18)	(0,02)	(0,02)	(0,05)
Ir	3,688**	3,987**	4,039**	6,808**	2,014*		4,710**	4,654**	0,441
	(0,00)	(0,00)	(0,00)	(0,00)	(0,05)		(0,00)	(0,00)	(0,89)
It	0,886	0,545	0,704	7,296**	0,662	0,539		1,340	0,754
	(0,53)	(0,82)	(0,69)	(0,00)	(0,72)	(0,82)		(0,23)	(0,64)
N	3,074**	1,476	2,078*	1,382	1,280	1,806	1,626		0,696
	(0,00)	(0,18)	(0,05)	(0,21)	(0,26)	(0,09)	(0,13)		(0,69)
S	2,726**	1,152	5,321**	2,836**	2,851**	2,564**	3,290**	1,776	
	(0,01)	(0,34)	(0,00)	(0,01)	(0,01)	(0,01)	(0,00)	(0,09)	

* significant at the 5% level; ** significant at the 1% level.
G = Germany (o), B = Belgium (a), D = Denmark (a), Fi = Finland (o), Fr = France (a), Ir = Ireland (a), It = Italy (a), N = Netherlands (o) and S = Spain (o)

Another peculiarity is the appearance of the Finnish interest rate in explaining the interest rates of several countries. This could be explained by the tequila effect discussed in the previous section. The contagion argument has often been applied to the EMS crises: in 1992 the French franc and Irish punt were attacked following the crisis with the British pound and the Italian lira, while the widening of the fluctuation bands in 1993 could be justified with the attack on the French franc that threatened to spill over to other EMS countries (Eichengreen et al. 1996, 1). This could explain the causal relations involving Finland: the European currency crises were perhaps visible in the Finnish interest rates before they were observable in those of the EMS countries.

The original Belgian interest rate is independent of Germany and is instead determined by Denmark, France and Ireland. When poor credibility is removed from the time series the adjusted interest rates of Denmark and France keep the positions, while Germany becomes again significant. This implies that Germany is significant in determining the credible Belgian interest rate, while the original, non-credible rate drifted with the Irish interest rate as well as the other non-credible rates in the system. This provides support to the assumption of the closeness between the Belgian, Danish and French economies that was indicated in the co-integration as well as the Granger causality tests for the entire period.

While Germany is significant in explaining the original Danish interest rate, this effect disappears when poor credibility is removed. Finland and Italy are significant in both equations. The original interest rate has interaction with the original French and Irish interest rates, whereas the adjusted one interacts with the Irish and Dutch rates. The difference in these results compared with the results for the whole period, could be explained with the use of a different interest rate: the official discount rate was used for the whole period, since the interbank rate was only available from January 1987. This implies that while the Danish authorities perhaps attempted to give more weight to German monetary policy, the markets appear to have grouped Denmark together with less stable Italy and Ireland. Since Finland has not been a member of the EMS, its influence on Denmark may partly be credited to the closeness of the Scandinavian economies.

The Finnish interest rate is Granger caused by Germany and the Netherlands with an interaction between the credible Italian interest rate. It would thus seem that Finland would be fairly close to the hard currency block of Germany and the Netherlands, which supports the outcome of the Johansen test, where one stochastic trend was found between these three countries. The close connection between the Finnish and Italian interest rates could be explained by the contagion argument: the crises in the two countries were almost simultaneous as were their entries to the ERM in the fall of 1996.

Removing poor credibility has no effect on the determinant variables of the French interest rate, which are Germany, Finland, Italy and the Netherlands. Bi-directional causality is observable with the Danish and Irish original interest rates as well as between the adjusted French and original Spanish rate. It would seem that in this period France followed besides the most credible economies, Germany and the Netherlands, also Finland and Italy. This result is therefore somewhat ambiguous. As suggested previously Finland can be grouped together with Germany and the Netherlands and this would indicate that France is following the group of the strong economies. Yet, the appearance of Italy among the determinant variables suggests that the French interest rate moves between the blocks, assuming that Italy were placed in the weak currency block as suggested by Weber. A possible explanation was offered earlier, where it was suggested that the

1992 crisis spread from Italy to France. It could thus be assumed that France has predominantly followed the hard currency block, but has time to time been less successful at it.

While the original Irish interest rate is still independent from Germany, Germany is one of the determinants of the credible Irish interest rate. The original interest rate depends on Italy and Finland and interacts with the Danish, French and Spanish rates. The adjusted rate has several determinants besides Germany: Belgium, Finland, France, Italy and the Netherlands, while interaction occurs with Denmark. In the previous chapter it was discovered that the adjusted Irish interest rate for this period was I(1), opposed to being stationary in the other tests, which gives this test more weight. It appears that the Irish interest rate follows the movements of the other EMS interest rates.

The earlier insulated Italian interest rates now show signs of foreign influences. According to the test on the original interest rate, there is one-way Granger causality going from Finland to Italy. When the interest rates in the two periods of 1992 are adjusted for poor credibility, this causality turns into interaction between the economies.

The Dutch interest rate is again solely determined by Germany. An interaction is found between the Dutch rate and the adjusted Danish rate. This supports the outcome of the Granger test for the whole period as well as the results from the co-integration analysis. Therefore, the outcome lends support to Weber's statement that Germany and the Netherlands practically already form a monetary union.

The main determinants of the Spanish rate are German, Finnish, French and Italian original interest rates with bi-directional causality between the Danish and Irish original interest rate, while the credibility adjustment changes the Danish and Irish rates as determinants and the French rate to the interaction category. The presence of German influences here can be explained with the Spanish participation in the EMS: it joined in 1989, and therefore it has been a member for most of this period.

The outcome for this period is in line with that for the entire period. The outcome from the Johansen test, where one stochastic trend was found between Germany, Finland and the

Netherlands is supported here. The causal relations within the other block implied by the Johansen procedure - France, Italy and Spain - are not as obvious. Credibility adjustment emphasizes the German and Dutch influence on this period as well, although not as clearly as in the results for the whole period. This could be adhered to the currency crises and the tequila effect. Surprisingly, the credibility adjustment did not remove the tequila effect, which was here mainly assumed to have spilled over from Finland and Italy. This supports the contradiction of the tequila effect, i.e. that investors only attack countries, where the fundamentals are weak.

Since the Irish and Spanish interest rates were I(1) in this period, some interpretation of their causal relations can be provided. Although the Spanish interest rate shows signs of German influence, it could be grouped together with the other southern economies, France and Italy, as was the outcome of the Johansen test. The Irish interest rate appears to be influenced by all of the other interest rates. The next section contemplates the changes in the causal relations brought by the widening of the fluctuation bands.

August 1993 - June 1997

The results of the Granger causality tests are presented for the last period interest rates in table 6.31. This period is characterized by the wider fluctuation bands that were set in force in August 1993. There are very few causal relationships in this period. This could be adhered to the absence of the exchange rate constraint: the interest rates were to free to move. Another possible explanation is that the amount of data was not sufficient for any significant results to be attained.

The Finnish interest rate is caused by the Danish rate. At the ten per cent level this could be interpreted as interaction. Finland and Ireland are causal to the French rate. Finland also causes the Italian rate as was already seen in the previous period. The Italian rate then in turn affects the Spanish rate. The explanation to these results may as well be the tequila effect.

Table 6.31 Granger Causality Tests: 8/1993 - 6/1997.
Dependent variable is on the vertical axis.

	G	B	D	Fi	Fr	Ir	It	N	S
G		1,072	0,860	1,618	0,860	0,216	1,360	1,283	1,091
		(0,42)	(0,56)	(0,18)	(0,56)	(0,98)	(0,27)	(0,30)	(0,41)
B	1,727		1,630		0,950	1,513	1,370	1,715	1,765
	(0,15)		(0,18)		(0,50)	(0,21)	(0,27)	(0,15)	(0,14)
D	0,984	1,491		2,155	0,272	1,630	1,225	1,556	0,617
	(0,48)	(0,22)		(0,08)	(0,97)	(0,18)	(0,33)	(0,20)	(0,75)
Fi	0,428	1,585	4,091*		1,771	0,521	1,701	1,344	0,478
	(0,89)	(0,19)	(0,00)		(0,14)	(0,83)	(0,16)	(0,28)	(0,86)
Fr	1,276	1,757	0,982	2,596*		4,459*	0,547	1,123	0,528
	(0,31)	(0,14)	(0,48)	(0,04)		(0,00)	(0,80)	(0,39)	(0,82)
Ir	1,593	1,853	1,234	1,204	1,163		0,881	0,879	1,073
	(0,19)	(0,12)	(0,33)	(0,34)	(0,37)		(0,55)	(0,55)	(0,42)
It	0,970	1,288	1,291	2,425*	0,664	1,019		0,895	0,867
	(0,49)	(0,30)	(0,30)	(0,05)	(0,72)	(0,45)		(0,54)	(0,56)
N	1,477	0,677	0,763	1,395	1,077	0,325	1,319		0,823
	(0,22)	(0,71)	(0,64)	(0,26)	(0,42)	(0,95)	(0,299		(0,59)
S	0,930	0,896	0,698	1,461	0,875	1,327	2,591*	0,616	
	(0,51)	(0,54)	(0,69)	(0,23)	(0,55)	(0,28)	(0,04)	(0,75)	

* significant at the 5% level; ** significant at the 1% level.
G = Germany, B = Belgium, D = Denmark, Fi = Finland, Fr = France, Ir = Ireland, It = Italy, N = Netherlands and S = Spain

6.5 Discussion

The Deutschmark has never been devaluated against the other EMS currencies and thus, it can be used as the benchmark of credibility for the other EMS members. Svensson's simplest test conducted on the bilateral DM-exchange rates revealed that the EMS countries using the narrower 2,25 per cent band - with the exception of the Netherlands - have been impaired by periods of poor credibility, especially in the 1980s. The last interest rates above the rate-of-return band were seen during the time of the EMS crises. The wider exchange rate bands, both the 6 and 15 per cent ones, have achieved better credibility.

The results of the co-integration tests appear to indicate that credibility is significant in proving the German dominance hypothesis. While the non-credible EMS interest rates move together, which in the case of domestic market interest rates implies that the markets have given these interest rates the same status, the credible rates seem to follow the German and Dutch economies, at least when the whole EMS period is considered. In the later period, May 1987 - June 1997, there seem to be two clearly identifiable blocks in the EMS: one between Germany, the Netherlands and Finland and another between France, Italy and Spain. The other countries were intermediate cases between these blocks that could, following Weber (1991), be considered the hard and soft currency blocks.

Granger causality tests reveal the meaning of credibility more clearly, although here as well it is most evident in the entire period. The corrected interest rates demonstrated less causal relations than the original rates. The ones that remained after the credibility adjustment were often the German and Dutch interest rates. In the second period the argument of two blocks in the EMS finds support. Since removing poor credibility removes the influences of other non-credible interest rates, it could be assumed that also the tequila effect, i.e. the spill over effect of a currency crisis to other countries, would disappear. The finding of the appearance of the tequila effect on the credible interest rates indicates that the contrasting view of the contagious currency crisis may be justified: contagion threatens only countries with weak fundamentals. Hence, it could be concluded that there are signs of German dominance in some of the EMS countries, but this influence of the German economy seems to be hidden behind the poor credibility of the country's commitment to fixed exchange rates.

7 CONCLUSIONS

Although the German dominance hypothesis has been the topic of a lot of research, the effects of poor credibility on the hypothesis have not been considered. The aim in this paper was to combine these issues. First, interest rates, which were used as the measure of monetary policy, were cleaned from poor credibility with Svensson's simplest test, where a rate-of-return band is built around the domestic interest rate. This band is based on the maximum and minimum expected rate of depreciation of the exchange rate within the fluctuation band. Then, after determining the order of integration of the variables, the convergence of EMS interest rates was tested using co-integration techniques. Both the Engle-Granger two-step procedure and the Johansen method were employed. Finally, the causal relations within the EMS were determined with Granger causality tests. The results on the German dominance hypothesis obtained using the credibility adjusted rates were compared with those of the original interest rates. Besides the whole EMS period, March 1979 - June 1997, two sub-periods were examined: May 1987 - June 1997 and August 1993 - June 1997.

The findings indicate that the credible interest rates in the EMS are influenced by Germany as well as the Netherlands, while the original rates of the member countries move together. The interpretation could be that the fundamentals in the economies follow the stronger economies but the markets expect the countries to deviate from this path. Since the tequila effect (contagious currency crisis) is still visible in the interest rates after the credibility adjustment, this view supports the argument of currency crisis only spilling over to countries with weak fundamentals.

When only the time period after 1987 is considered, two blocks seem to be identifiable within the EMS: one with Germany, the Netherlands and Finland and another with France, Italy and Spain. The smaller economies - Belgium, Denmark and Ireland - are intermediate cases, which can not be considered as a third block based on the co-integration procedure. Therefore, the results lend support to Weber's (1991) bipolar theory of the EMS, where a hard currency block was centered around the Bundesbank and a softer option was offered by France. Nevertheless, in the causality tests for the same period the French interest rate was affected by all of the hard block countries as well as Italy. It would appear that the southern economies have adopted the French policy, which then follows the policies in Germany.

When earlier co-integration analysis is considered, the results are similar. For example the latest study from Siklos and Wohar (1997) found a consistent number of stochastic trends among the EMS Euro-deposit rates as was found here among domestic rates. The blocks, however, were not the same. They found one block between Germany, the Netherlands and Belgium and another between Germany, the Netherlands and France. The difference may be adhered to the use of different interest rates. Causality tests have in most cases provided support for the German dominance hypothesis. Here the outcome from the Granger causality tests and the omitted variables tests were also in favor of the asymmetry hypothesis: Germany appeared significant in determining most of the interest rates. The results obtained from estimating De Grauwe's model on interest rates and realignments support the assertion of Beyer and Schmidt that the model may be biased.

The findings suggest that Germany is an important monetary authority in Europe. It would seem that Germany affects the fundamentals that determine the interest rate but this influence is covered by the poor credibility of the EMS countries. This power appears to have diminished to some extent since the EMS crises. However, Germany still seems to be the determinant power in the EMS, which should be considered when forming the European central bank, i.e. if Germany's role in guaranteeing the working of the EMS is crucial, this has important implications for the future working of the EMS as well as the monetary union.

It appears that the data set was not sufficient to determine the effects of the wider fluctuation bands on the German dominance hypothesis. Thus, the issue is left for future research. The credibility measure used here is very simple and it fails to account for exchange rate movements within the band, i.e. the interest rate differential is not only affected by the possibility of realignments, but as well by movements within the band, which do not signal poor credibility (e.g. Svensson 1991a). The results might change if a more developed measure of credibility was used. An important limitation in the co-integration procedure was the relatively large number of variables, which complicated the determination of the co-integrating vectors.

An interesting consideration would be the use of official interest rates instead of market rates. The results with the Danish official rate support the conclusion that the fundamentals of the interest rates follow Germany and the Netherlands, thus performing the credibility adjusted test for other official rates could provide further support for this conclusion. The effects of poor credibility on the conduct of monetary policy should as well be considered. Hence, a suggestion for further research would include the official interest rates as well as the market rates and examine the German dominance with a model that would take into account the effect of poor credibility on conduct of monetary policy. If convergence of the fundamentals in the economies has been achieved, the transfer to the monetary union seems favorable. Nevertheless, if convergence has been achieved through German dominance in the EMS, this should be considered when forming conduct of monetary policy in the future.

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APPENDIX

LIST OF FIGURES

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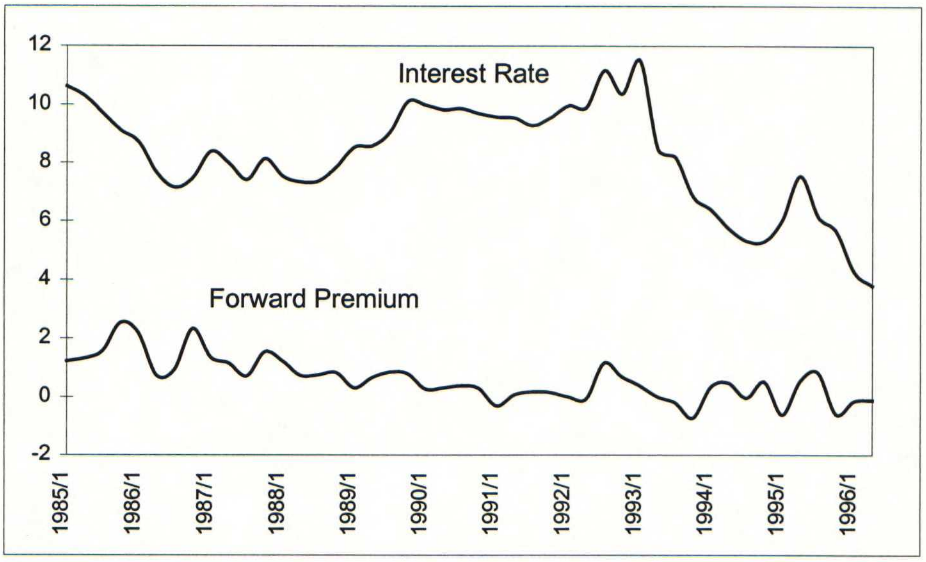

Figure 1 French Short-term Interest Rate and Forward Premium FF/DM

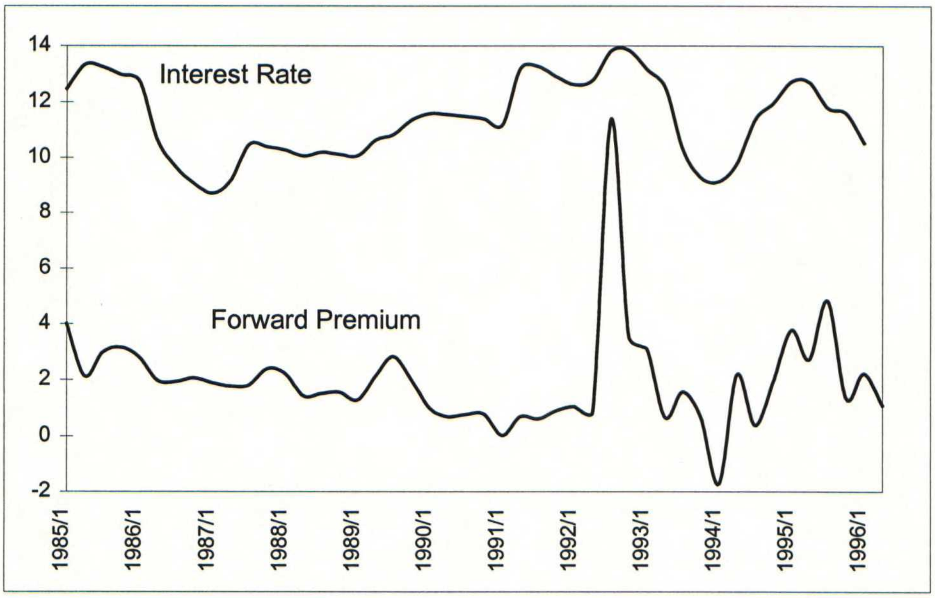

Figure 2 Italian Long-term Interest Rate and Forward Premium ITL/DM

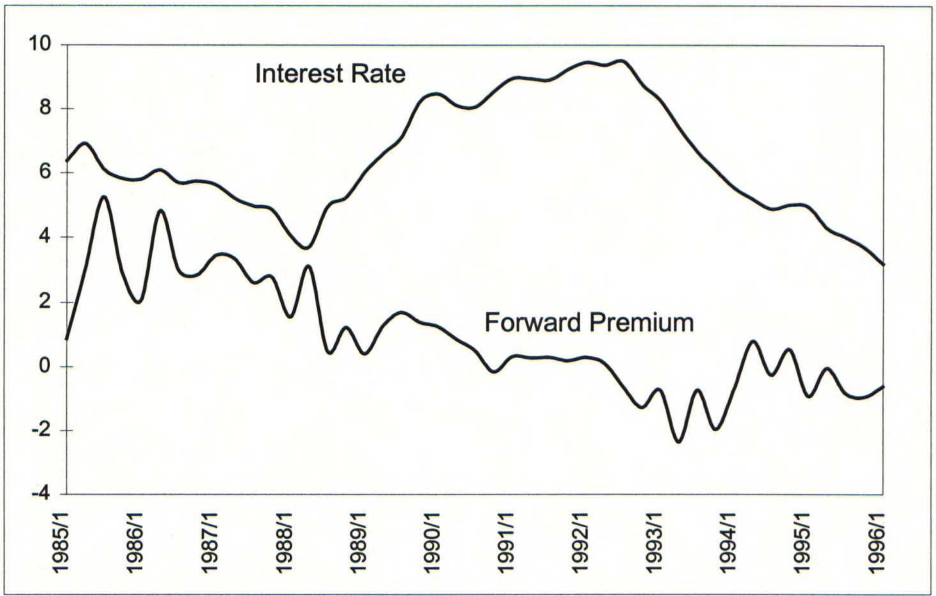

Figure 3 Dutch Short-term Interest Rate and Forward Premium NLG/DM

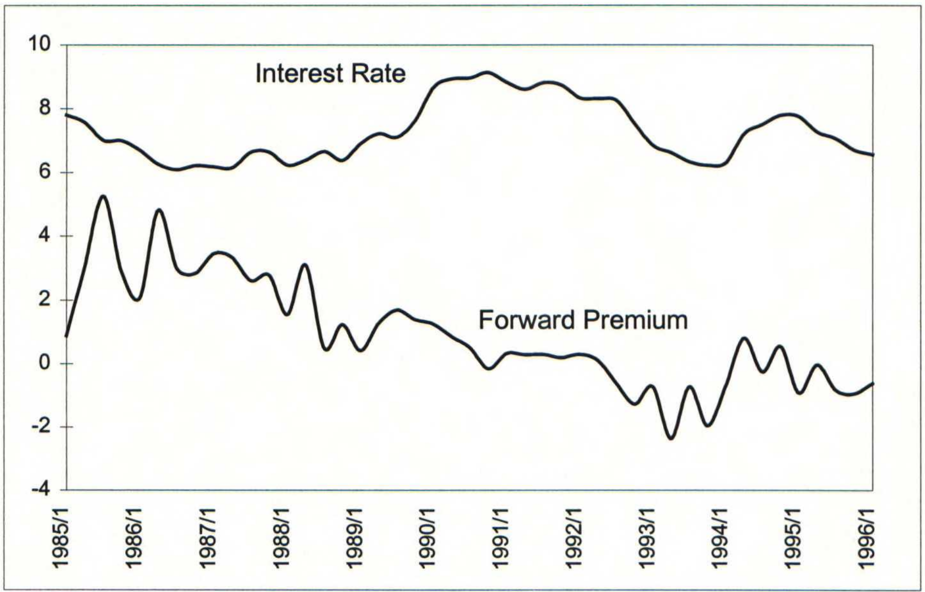

Figure 4 Dutch Long-term Interest Rate and Forward Premium NLG/DM

Table 1 Unit Root Tests for Levels of Data, 4/1979 - 6/1997.
Original and adjusted interest rates with 0, 1 and 4 lags.

Country			**Dickey-Fuller**			**Phillips-Perron**	
Germany		-0,689	-1,262	-1,479	-0,692	-0,928	-1,189
Belgium	(o)	-0,775	-1,260	-0,994	-0,779	-0,991	-1,071
	(a)	-2,593	-2,442	-1,465	-2,605	-2,547	-2,296
Denmark	(o)	-0,345	-0,657	-0,719	-0,346	-0,490	-0,576
	(a)	-3,435*	-2,007	-0,820	-3,451*	-2,793	-2,544
France	(o)	-0,757	-1,297	-0,994	-0,760	-1,008	-1,182
	(a)	-1,665	-1,374	-0,749	-1,672	-1,560	-1,360
Ireland	(o)	-10,578*	-4,837*	-4,311*	-10,808*	-10,576*	-11,574*
	(a)	-4,131*	-2,709	-1,766	-4,150*	-3,587*	-3,468*
Italy	(o)	-0,572	-1,046	-0,921	-0,575	-0,775	-0,965
	(a)	-1,242	-0,709	-0,952	-1,247	-0,957	-1,003
Netherlands		-1,076	-1,324	-1,604	-1,081	-1,202	-1,422
Spain		-3,549*	-3,305*	-1,869	-3,565*	-3,425*	-3,168*

* the presence of a unit root is rejected at the 5% level (critical value -2,88).

Table 2 Unit Root Tests for First Differences of Data, 4/1979 - 6/1997.
Original and adjusted rates with 0,1 and 4 lags.

Country			**Dickey-Fuller**			**Phillips-Perron**	
Germany		-10,283	-8,972	-4,964	-10,331	-10,356	-10,322
Belgium	(o)	-11,431	-10,236	-6,463	-11,484	-11,475	-11,310
	(a)	-15,933	-11,471	-9,417	-16,006	-16,002	-16,324
Denmark	(o)	-12,597	-10,317	-5,551	-12,656	-12,664	-12,620
	(a)	-22,845	-17,187	-8,287	-22,951	-23,699	-27,363
France	(o)	-11,051	-9,761	-7,082	-11,103	-11,128	-11,014
	(a)	-16,410	-12,854	-7,400	-16,487	-16,508	-16,821
Ireland	(o)	-33,843	-15,367	-8,787	-34,002	-35,119	-38,661
	(a)	-22,176	-13,537	-9,681	-22,278	-22,449	-25,539
Italy	(o)	-11,450	-8,378	-6,807	-11,503	-11,479	-11,544
	(a)	-19,287	-11,038	-6,971	-19,376	-19,341	-19,060
Netherlands		-12,894	-9,364	-5,855	-12,954	-12,948	-13,037
Spain		-16,975	-14,825	-8,497	-17,054	-17,049	-17,782

The critical value at the 5% level is -2,88.

Table 3 Unit Root Tests for Levels of Data, 5/1987 - 6/1997.
Original (o) and adjusted (a) data with 0,1, and 4 lags.

Country		**Dickey-Fuller**			**Phillips-Perron**		
Germany		-0,307	-0,642	-0,794	-0,310	-0,435	-0,610
Belgium	**(o)**	-0,249	-0,658	-0,079	-0,250	-0,424	-0,365
	(a)	-0,612	-0,578	-0,138	-0,617	-0,607	-0,426
Denmark	**(o)**	-2,077	-1,148	-0,638	-2,094	-1,643	-1,509
	(a)	-1,458	-0,985	-0,721	-1,470	-1,252	-1,146
Finland		-0,334	-1,007	-0,474	-0,337	-0,598	-0,624
France	**(o)**	-0,380	-0,814	-0,176	-0,383	-0,574	-0,490
	(a)	-1,148	-1,033	-0,456	-1,158	-1,115	-0,914
Ireland	**(o)**	-9,146*	-4,071*	-3,723*	-9,223*	-9,161*	-9,755*
	(a)	-2,129	-1,425	-1,193	-2,147	-1,914	-1,924
Italy	**(o)**	-1,084	-1,252	-1,464	-1,093	-1,190	-1,453
	(a)	-2,481	-1,128	-1,380	-2,502	-1,883	-2,064
Netherlands		-0,081	-0,491	-0,844	-0,082	-0,251	-0,484
Spain		-1,871	-1,056	-2,170	-1,887	-1,886	-1,981

* The presence of a unit root is rejected at the 5% level (critical value -2,88).

Table 4 Unit Root Tests for First Differences of Data, 5/1987 - 6/1997.
Original (o) and adjusted (a) data with 0, 1 and 4 lags.

Country		**Dickey-Fuller**			**Phillips-Perron**		
Germany		-7,895	-5,817	-3,491	-7,961	-7,932	-8,085
Belgium	(o)	-8,650	-7,144	-4,926	-8,723	-8,740	-8,568
	(a)	-11,106	-8,393	-5,302	-11,120	-11,200	-11,309
Denmark	(o)	-16,304	-10,096	-4,943	-16,442	-16,593	-17,373
	(a)	-13,679	-9,203	-5,611	-13,795	-13,825	-14,021
Finland		-7,327	-7,176	-4,806	-7,389	-7,480	-7,144
France	(o)	-8,792	-7,669	-4,750	-8,866	-8,892	-8,713
	(a)	-11,543	-8,843	-5,755	-11,640	-11,642	-11,827
Ireland	(o)	-25,815	-11,239	-6,457	-26,033	-26,878	-29,594
	(a)	-15,466	-10,619	-4,625	-15,597	-15,841	-15,798
Italy	(o)	-10,168	-6,386	-5,363	-10,253	-10,251	-10,318
	(a)	-17,820	-10,238	-5,054	-17,970	-18,186	-17,982
Netherlands		-7,850	-6,023	-3,468	-7,916	-7,898	-8,050
Spain		-9,502	-5,047	-2,792*	-9,582	-9,574	-9,891

* The presence of a unit root is accepted at the 5% level (critical value -2,89).

Table 5 Unit Root Tests for Levels of Data, 8/1993 - 6/1997.
Original data with 0, 1 and 4 lags.

Country		**Dickey-Fuller**			**Phillips-Perron**	
Germany	-1,862	-1,952	-1,534	-1,904	-1,800	-1,806
Belgium	-3,341*	-4,629*	-1,644	-3,416*	-3,512*	-3,615*
Denmark	-3,173*	-2,905	-0,685	-3,244*	-3,220*	-2,963*
Finland	-0,730	-1,241	-0,341	-0,746	-0,873	-0,977
France	-1,433	-1,154	-0,829	-1,466	-1,479	-1,504
Ireland	-3,033*	-2,364	-3,450*	-3,101*	-2,862	-2,969*
Italy	-0,491	-0,627	-0,933	-0,502	-0,584	-0,708
Netherlands	-1,949	-1,919	-1,160	-1,993	-1,875	-1,827
Spain	-0,852	-0,555	-1,020	-0,871	-0,918	-1,194

* The presence of a unit root is rejected at the 5% level (critical value -2,93).

Table 6 Unit Root Tests for First Differences of Data, 8/1993 - 6/1997.
Original data with 0, 1 and 4 lags.

Country		**Dickey-Fuller**			**Phillips-Perron**	
Germany	-5,002	-4,154	-2,450*	-5,117	-5,123	-5,095
Belgium	-5,951	-3,426	-2,857*	-6,087	-6,097	-6,283
Denmark	-5,880	-4,218	-4,064	-6,015	-5,996	-6,085
Finland	-4,317	-3,171	-3,237	-4,416	-4,365	-4,420
France	-6,604	-4,614	-3,108	-6,756	-6,760	-6,767
Ireland	-11,163	-5,410	-2,419*	-11,420	-11,393	-11,194
Italy	-6,105	-5,059	-2,136*	-6,245	-6,246	-6,253
Netherlands	-4,685	-4,183	-2,655*	-4,792	-4,823	-4,789
Spain	-6,115	-3,158	-1,942*	-6,256	-6,261	-6,463

* The presence of a unit root is accepted at the 5% level (critical value -2,93).

Table 7 Long-run Relationships: Original Data, 4/1979 - 6/1997.
Dependent variable is on the vertical axis and *t*-statistics in parentheses.

**	Const.	G	B	D	Fr	Ir	It	N	S
G	-0,504		-0,050	0,075	0,132*	-0,045*	0,064	0,905*	-0,048*
	(-1,80)		(-0,92)	(1,21)	(2,12)	(-3,20)	(1,65)	(17,40)	(-2,21)
B	-1,868*	-0,079		0,421*	0,460*	0,030	0,227*	0,276*	-0,109*
	(-5,70)	(-0,918)		(5.80)	(6,37)	(1,67)	(4,87)	(2,77)	(-4,11)
D	1,221*	0,092	0,327*		0,015	0,029	-0,084	0,336*	0,106*
	(4,09)	(1,21)	(5,80)		(0,22)	(1,84)	(-1,95)	(3,89)	(4,59)
Fr	-1,211	0,158*	0,351*	0,015		-0,018	0,332*	0,068	0,131*
	(-4,086)	(2,12)	(6,37)	(0,22)		(-1,21)	(9,08)	(0,77)	(5,89)
Ir	-3,683*	-1,038*	0,440	0,550	-0,367		0,692*	1,082*	0,046
	(-2,76)	(-3,20)	(1,67)	(1,84)	(-1,21)		(3,76)	(2,81)	(0,44)
It	4,614*	0,197	0,444*	-0,211	0,847*	0,091*		-0,707*	0,053
	(12,28)	(1,65)	(4,87)	(-1,95)	(9,08)	(3,76)		(-5,30)	(1,39)
N	1,089*	0,651*	0,127*	0,199*	0,041	0,033*	-0,167*		0,002
	(4,80)	(17,40)	(2,77)	(3,89)	(0,77)	(2,81)	(-5,30)		(0,12)
S	2,710*	-0,471*	-0,681*	0,856*	1,076*	0,020	0,170	0,030	
	(3,15)	(-2,21)	(-4,12)	(4,59)	(5,89)	(0,44)	(1,39)	(0,12)	

* significant at the 5% level.

** G = Germany, B = Belgium, D = Denmark, Fr = France, Ir = Ireland, It = Italy, N = Netherlands and S = Spain

Table 8 Long-run Relationships: Original (o) and Adjusted (a) Data, 4/1979 - 6/1997.
Dependent variable is on the vertical axis and *t*- statistics in parentheses.

**	Const.	G	B	D	Fr	Ir	It	N	S
G	-0,542*		0,160*	0,090*	0,055	-0,178*	0,081*	0,856*	-0,022
	(-2,33)		(3,50)	(2,08)	(1,01)	(-6,87)	(2,51)	(18,52)	(-1,12)
B	-0,329	0,343*		0,202*	0,207*	0,366*	-0,023	0,056	-0,064*
	(-0,95)	(3,50)		(3,26)	(2,67)	(10,84)	(-0,48)	(0,51)	(-2,20)
D	0,517	0,225*	0,237*		0,035	-0,009	0,029	0,214	0,121*
	(1,39)	(2,08)	(3,26)		(0,41)	(-0,21)	(0,56)	(1,81)	(3,93)
Fr	-1,627*	0,089	0,157*	0,022		0,023	0,417*	0,224*	0,124*
	(-5,82)	(1,01)	(2,67)	(0,41)		(0,62)	(13,95)	(2,38)	(5,16)
Ir	-1,182*	-1,024*	0,979*	-0,022	0,080		0,229*	0,788*	0,092
	(-2,11)	(-6,87)	(10,84)	(-0,21)	(0,62)		(3,00)	(4,61)	(1,92)
It	4,138*	0,361*	-0,048	0,052	1,151*	0,179*		-0,868*	-0,005
	(10,06)	(2,51)	(-0,48)	(0,56)	(13,95)	(3,00)		(-5,90)	(-0,11)
N	1,164*	0,723*	0,022	0,072	0,117*	0,116*	-0,163*		-0,011
	(5,77)	(18,52)	(0,51)	(1,81)	(2,38)	(4,61)	(-5,90)		(-0,61)
S	4,183*	-0,263	-0,350	0,566*	0,901*	0,188	-0,012	-0,157	
	(5,52)	(-1,12)	(-2,20)	(3,93)	(5,16)	(1,92)	(-0,11)	(-0,61)	

* significant at the 5% level.

** G = Germany, B = Belgium, D = Denmark, Fr = France, Ir = Ireland, It = Italy, N = Netherlands and S = Spain

Table 9 Unit Root Tests for the Residuals: Original Data, 4/1979 - 6/1997

Country	D-F	ADF(1)	ADF(4)
Germany	-4,668	-4,244	-3,675
Belgium	-4,928	-5,411	-4,128
Denmark	-4,291	-4,414	-3,521
France	-5,759*	-6,839*	-5,614*
Ireland	-12,089*	-6,776*	-6,234*
Italy	-4,534	-5,128	-4,560
Netherlands	-5,379	-5,525*	-4,645
Spain	-7,017*	-7,403*	-4,549

* approximated significant at the 5% level.

Table 10 Unit Root Tests for the Residuals: Original (o) and Adjusted (a)Data, 4/1979 - 6/1997

Country	D-F	ADF(1)	ADF(4)
Germany	-6,289*	-4,189	-3,517
Belgium	-7,411*	-7,331*	-5,482*
Denmark	-9,036*	-7,009*	-4,228
France	-8,086*	-7,101*	-5,227
Ireland	-10,180*	-6,798*	-4,525
Italy	-7,218*	-5,685	-4,394
Netherlands	-6,389*	-5,417	-4,417
Spain	-7,107*	-7,028*	-4,385

* approximated significant at the 5% level.

Table 11 Bivariate Long-run Relationships, 4/1979 - 6/1997.
The other EMS countries and Germany (regressor) (*t*-statistics in parentheses).

	Original		Adjusted	
	Constant	**Germany**	**Constant**	**Germany**
Belgium	1,790*	1,086*	1,482*	1,049*
	(4,43)	(19,29)	(4,12)	(20,91)
Denmark	2,469*	0,793*	2,350*	0,791*
	(10,04)	(23,14)	(8,50)	(20,52)
France	3,106*	0,956*	3,221*	0,920*
	(7,70)	(17,02)	(8,11)	(16,62)
Italy	7,760*	0,832*	7,822*	0,819*
	(13,03)	(10,02)	(13,03)	(9,79)
Netherlands	0,793*	0,885*		
	(5,20)	(41,59)		

* significant at the 5% level.

Table 12 Bivariate Long-run Relationships, 4/1979 - 6/1997.
Germany and the other EMS countries (regressors) (*t*-statistics in parentheses).

Original		**Adjusted**	
Constant	**Belgium**	**Constant**	**Belgium**
1,439* (4,91)	0,581* (19,29)	1,289* (4,64)	0,637* (20,91)
Constant	**Denmark**	**Constant**	**Denmark**
-0,273 (-0,86)	0,897* (23,14)	0,328 (1,00)	0,834* (20,52)
Constant	**France**	**Constant**	**France**
1,028* (2,91)	0,598* (17,02)	1,001* (2,76)	0,609* (16,62)
Constant	**Italy**	**Constant**	**Italy**
1,650* (3,14)	0,380* (10,02)	1,744* (3,30)	0,374* (9,79)
Constant	**Netherlands**	**Constant**	**Netherlands**
-0,046 (-0,27)	1,004* (41,59)		

* significant at the 5% level.

Table 13 Long-run Relationships: Original Data, 5/1987 - 6/1997.
Dependent variable on the vertical axis.

**	Const.	G	B	D	Fi	Fr	Ir	It	N	S
G	-0,142		0,149*	-0,005	-0,066*	0,018	0,003	0,103*	0,976*	-0,117*
	(-0,56)		(2,92)	(-0,167)	(-2,62)	(0,34)	(0,92)	(2,99)	(29,94)	(-6,09)
B	1,973*	0,471*		0,120*	0,224*	0,294*	-0,015*	-0,300*	-0,074	0,058
	(4,79)	(2,92)		(2,31)	(5,44)	(3,17)	(-2,36)	(-5,26)	(-0,42)	(1,49)
D	-1,442	0,373	0,373*		-0,185*	0,825*	0,018	0,029	-0,002	0,193*
	(-1,84)	(-0,17)	(2,31)		(-2,32)	(5,44)	(1,58)	(0,26)	(-0,01)	(2,88)
Fi	-6,595*	-0,864*	0,925*	-0,246*		0,298	-0,010	0,731*	0,901*	0,078
	(-9,77)	(-2,62)	(5,44)	(-2,32)		(1,53)	(-0,79)	(6,67)	(2,60)	(0,97)
Fr	-0,447	0,055	0,278*	0,252*	0,068		0,012	0,208*	0,001	0,075*
	(-1,02)	(0,34)	(3,17)	(5,44)	(1,53)		(1,86)	(3,54)	(0,01)	(1,99)
Ir	-6,918	2,189	-3,109*	1,198	-0,523	2,535		0,356	-0,744	0,012
	(-1,07)	(0,92)	(-2,36)	(1,58)	(-0,79)	(1,86)		(0,39)	(-0,30)	(0,02)
It	5,804*	0,710*	-0,655*	0,021	0,387*	0,479*	0,004		-0,538*	0,097
	(15,14)	(2,99)	(-5,26)	(0,26)	(6,67)	(3,54)	(0,39)		(-2,12)	(1,68)
N	0,049	0,886*	-0,021	-0,000	0,063*	0,000	-0,001	-0,071*		0,082*
	(0,20)	(26,94)	(-0,42)	(-0,01)	(2,60)	(0,01)	(-0,30)	(-2,12)		(4,19)
S	2,019	-2,109*	0,331	0,355*	0,107	0,453*	0,000	0,253	1,635*	
	(1,90)	(-6,08)	(1,49)	(2,88)	(0,97)	(1,99)	(0,02)	(1,68)	(4,19)	

* significant at the 5% level.
** G = Germany, B = Belgium, D = Denmark, Fi = Finland, Fr = France, Ir = Ireland, It = Italy, N = Netherlands and S = Spain

Table 14 Unit Root Tests for the Residuals: Original Data, 5/1987 - 6/1997

Country	D-F	ADF(1)	ADF(4)
Germany	-4,020	-4,625	-3,915
Belgium	-5,204	-4,701	-3,668
Denmark	-8,368*	-5,320	-3,709
Finland	-4,631	-4,997	-4,665
France	-5,522	-4,602	-4,477
Ireland	-13,664*	-6,229*	-4,903
Italy	-4,623	-4,830	-3,984
Netherlands	-3,450	-4,018	-3,333
Spain	-4,170	-3,820	-4,040

* approximated significant at the 5% level.

Table 15 Bivariate Long-run Relationships, 5/1987 - 6/1997. The other EMS countries and Germany (regressor) (*t*-statistics in parentheses).

	Original		**Adjusted**	
	Constant	**Germany**	**Constant**	**Germany**
Belgium	1,465*	0,899*	1,464*	0,895*
	(5,27)	(21,51)	(5,33)	(21,67)
Denmark	2,636*	0,918*	2,599*	0,868*
	(5,27)	(12,21)	(6,08)	(13,50)
Finland	0,575	1,377*		
	(0,93)	(14,74)		
France	2,610*	0,839*	2,451*	0,850*
	(7,39)	(15,80)	(6,97)	(16,06)
Italy	6,956*	0,633*	7,110*	0,601*
	(18,45)	(11,16)	(18,87)	(10,60)
Netherlands	0,106	0,973*		
	(0,99)	(60,38)		
Spain	6,617*	0,793*		
	(9,24)	(7,36)		

* significant at the 5% level.

Table 16 Bivariate Long-run Relationships, 4/1979 - 6/1997. Germany and the other EMS countries (regressors) (*t*-statistics in parentheses).

Original		Adjusted	
Constant	**Belgium**	**Constant**	**Belgium**
-0,007 (-0,02)	0,883* (21,51)	-0,033 (-0,11)	0,890* (21,67)
Constant	**Denmark**	**Constant**	**Denmark**
1,194* (2,74)	0,603* (12,21)	0,673 (1,56)	0,695* (13,50)
Constant	**Finland**	**Constant**	**Finland**
1,953* (6,17)	0,468* (14,74)		
Constant	**France**	**Constant**	**France**
-0,075 (-0,18)	0,805* (15,80)	0,014 (0,03)	0,803* (16,06)
Constant	**Italy**	**Constant**	**Italy**
-2,536* (3,17)	0,805* (11,16)	-2,498* (-2,98)	0,805* (10,60)
Constant	**Netherlands**	**Constant**	**Netherlands**
0,094 (0,86)	0,995* (60,38)		
Constant	**Spain**		
1,707* (2,67)	0,392* (7,36)		

* significant at the 5% level.

Table 17 Tests of Co-integration Rank: Original Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	8	0,366	98,97*	51,42	309,97*	156,00
1	7	0,258	64,76*	45,28	211,00*	124,24
2	6	0,252	63,12*	39,37	146,24*	94,15
3	5	0,157	37,15*	33,46	83,12*	68,52
4	4	0,117	27,07	27,07	45,97	47,21
5	3	0,058	13,04	20,97	18,89	29,68
6	2	0,021	4,54	14,07	5,85	15,41
7	1	0,006	1,31	3,76	1,31	3,76

* rejection at the 5% level.

Table 18 Tests of Co-integration Rank: Original and Adjusted Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	8	0,279	70,83*	51,42	287,87*	156,00
1	7	0,238	59,10*	45,28	217,04*	124,24
2	6	0,230	56,79*	39,37	157,94*	94,15
3	5	0,198	47,81*	33,46	101,15*	68,52
4	4	0,121	27,87*	27,07	53,35*	47,21
5	3	0,078	17,70	20,97	25,48	29,68
6	2	0,030	6,62	14,07	7,78	15,41
7	1	0,005	1,16	3,76	1,16	3,76

* rejection at the 5% level.

Table 19 Tests of Co-integration Rank: Original Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	8	0,279	70,83*	51,42	287,87*	156,00
1	7	0,238	59,10*	45,28	217,04*	124,24
2	6	0,230	56,79*	39,37	157,94*	94,15
3	5	0,198	47,81*	33,46	101,15*	68,52
4	4	0,121	27,87*	27,07	53,35*	47,21
5	3	0,078	17,70	20,97	25,48	29,68
6	2	0,030	6,62	14,07	7,78	15,41
7	1	0,005	1,16	3,76	1,16	3,76

* rejection at the 5% level.

Table 20 Tests of Co-integration Rank: Original German, Belgian, Danish, French and Dutch Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	5	0,208	50,55*	33,46	99,39*	68,52
1	4	0,125	29,03*	27,07	48,83*	47,21
2	3	0,060	13,50	20,97	19,80	29,68
3	2	0,019	4,22	14,07	6,30	15,41
4	1	0,010	2,08	3,76	2,08	3,76

* rejection at the 5% level.

Table 21 Tests of Co-integration Rank: Original German, Belgian, Danish and French Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	4	0,136	31,74*	27,07	49,57*	47,21
1	3	0,054	12,02	20,97	17,83	29,68
2	2	0,023	5,11	14,07	5,81	15,41
3	1	0,003	0,70	3,76	0,70	3,76

* rejection at the 5% level.

Table 22 Tests of Co-integration Rank: Original German, Belgian, Danish and Dutch Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	4	0,217	53,06*	27,07	75,43*	47,21
1	3	0,071	15,88	20,97	22,37	29,68
2	2	0,024	5,25	14,07	6,48	15,41
3	1	0,006	1,23	3,76	1,23	3,76

* rejection at the 5% level.

Table 23 Tests of Co-integration Rank: Original German, Belgian and Danish Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,074	16,66	20,97	22,41	29,68
1	2	0,024	5,26	14,07	5,75	15,41
2	1	0,002	0,50	3,76	0,50	3,76

* rejection at the 5% level.

Table 24 Tests of Co-integration Rank: Original German and Dutch Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	2	0,079	17,81*	14,07	19,23*	15,41
1	1	0,007	1,42	3,76	1,42	3,76

* rejection at the 5% level.

Table 25 Tests of Co-integration Rank: Original Belgian, Danish, French, Italian and Dutch Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	5	0,172	40,92*	33,46	103,51*	68,52
1	4	0,138	32,25*	27,07	62,59*	47,21
2	3	0,099	22,71*	20,97	30,34*	29,68
3	2	0,026	5,65	14,07	7,63	15,41
4	1	0,009	1,98	3,76	1,98	3,76

* rejection at the 5% level.

Table 26 Tests of Co-integration Rank: Original Belgian, Danish, French and Dutch Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	4	0,143	33,61*	27,07	67,64*	47,21
1	3	0,119	27,38*	20,97	34,03*	29,68
2	2	0,025	5,48	14,07	6,65	15,41
3	1	0,005	1,17	3,76	1,17	3,76

* rejection at the 5% level.

Table 27 Tests of Co-integration Rank: Original Belgian, Danish, French and Dutch Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	4	0,158	37,29*	27,07	68,56*	47,21
1	3	0,106	24,38*	20,97	31,27*	29,68
2	2	0,024	5,35	14,07	6,89	15,41
3	1	0,007	1,54	3,76	1,54	3,76

* rejection at the 5% level.

Table 28 Tests of Co-integration Rank: Original Belgian, Danish and French Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,117	26,90*	20,97	35,18*	29,68
1	2	0,034	7,49	14,07	8,28	15,41
2	1	0,004	0,79	3,76	0,79	3,76

* rejection at the 5% level.

Table 29 Tests of Co-integration Rank: Original Belgian, Danish and Italian Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,132	30,61*	20,97	37,88*	29,68
1	2	0,028	6,09	14,07	7,28	15,41
2	1	0,005	1,18	3,76	1,18	3,76

* rejection at the 5% level.

Table 30 Tests of Co-integration Rank: Original Belgian, Danish and Dutch Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,155	36,46*	20,97	45,35*	29,68
1	2	0,034	7,62	14,07	8,89	15,41
2	1	0,006	1,28	3,76	1,28	3,76

* rejection at the 5% level.

Table 31 Tests of Co-integration Rank: Original Belgian, French and Italian Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,127	29,51*	20,97	47,81*	29,68
1	2	0,076	17,11*	14,07	18,30*	15,41
2	1	0,005	1,19	3,76	1,19	3,76

* rejection at the 5% level.

Table 32 Tests of Co-integration Rank: Original Belgian, French and Dutch Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,110	25,20*	20,97	34,07*	29,68
1	2	0,033	7,30	14,07	8,87	15,41
2	1	0,007	1,57	3,76	1,57	3,76

* rejection at the 5% level.

Table 33 Tests of Co-integration Rank: Original Danish, French and Italian Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,137	32,07*	20,97	39,11*	29,68
1	2	0,029	6,50	14,07	7,04	15,41
2	1	0,003	0,55	3,76	0,55	3,76

* rejection at the 5% level.

Table 34 Tests of Co-integration Rank: Original Danish, French and Dutch Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,151	35,65*	20,97	43,89*	29,68
1	2	0,032	7,12	14,07	8,24	15,41
2	1	0,001	1,12	3,76	1,12	3,76

* rejection at the 5% level.

Table 35 Tests of Co-integration Rank: German (o), Belgian (a), Danish (a), French (a) and Dutch (o) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	5	0,217	53,02*	33,46	127,74*	68,52
1	4	0,195	47,09*	27,07	74,72*	47,21
2	3	0,079	17,81	20,97	27,63	29,68
3	2	0,040	8,78	14,07	9,82	15,41
4	1	0,005	1,05	3,76	1,05	3,76

* rejection at the 5% level.

Table 36 Tests of Co-integration Rank: German (o) and Belgian (a), Danish (a) and French (a) Data, 4/1979 - 6/1997.

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	4	0,223	54,77*	27,07	95,29*	47,21
1	3	0,133	30,90*	20,97	40,52*	29,68
2	2	0,039	8,65	14,07	9,63	15,41
3	1	0,005	0,98	3,76	0,98	3,76

* rejection at the 5% level.

Table 37 Tests of Co-integration Rank: German (o), adjusted Belgian (a), Danish (a) and Dutch (o) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	4	0,215	52,69*	27,07	95,25*	47,21
1	3	0,122	28,22*	20,97	42,56*	29,68
2	2	0,061	13,57	14,07	14,34	15,41
3	1	0,004	0,77	3,76	0,77	3,76

* rejection at the 5% level.

Table 38 Tests of Co-integration Rank: German (o), Belgian (a) and Danish (a) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,215	52,51*	20,97	69,16*	29,68
1	2	0,070	15,85*	14,07	16,64*	15,41
2	1	0,004	0,80	3,76	0,80	3,76

* rejection at the 5% level.

Table 39 Tests of Co-integration Rank: Belgian (a), Danish (a), French (a), Italian (a) and Dutch (o) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	5	0,234	57,78*	33,46	145,19*	68,52
1	4	0,173	41,25*	27,07	87,40*	47,21
2	3	0,150	35,38*	20,97	46,16*	29,68
3	2	0,042	9,40	14,07	10,78	15,41
4	1	0,006	1,38	3,76	1,38	3,76

* rejection at the 5% level.

Table 40 Tests of Co-integration Rank: Adjusted Belgian, Danish, French and Italian Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	4	0,209	50,83*	27,07	98,82*	47,21
1	3	0,149	35,04*	20,97	47,99*	29,68
2	2	0,056	12,51	14,07	12,95	15,41
3	1	0,002	0,44	3,76	0,44	3,76

* rejection at the 5% level.

Table 41 Tests of Co-integration Rank: Belgian (a), Danish (a), French (a) and Dutch (o) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	4	0,158	37,29*	27,07	68,56*	47,21
1	3	0,106	24,38*	20,97	31,27*	29,68
2	2	0,024	5,35	14,07	6,89	15,41
3	1	0,007	1,54	3,76	1,54	3,76

* rejection at the 5% level.

Table 42 Tests of Co-integration Rank: Adjusted Belgian, Danish and French Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,191	45,87*	20,97	68,22*	29,68
1	2	0,093	21,09*	14,07	22,34*	15,41
2	1	0,006	1,25	3,76	1,25	3,76

* rejection at the 5% level.

Table 43 Tests of Co-integration Rank: Adjusted Belgian, Danish and Italian Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,202	48,83*	20,97	61,71*	29,68
1	2	0,056	12,41	14,07	12,88	15,41
2	1	0,002	0,46	3,76	0,46	3,76

* rejection at the 5% level.

Table 44 Tests of Co-integration Rank: Belgian (a), Danish (a) and Dutch (o) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,212	51,65*	20,97	76,55*	29,68
1	2	0,105	24,17*	14,07	24,90*	15,41
2	1	0,003	0,73	3,76	0,73	3,76

* rejection at the 5% level.

Table 45 Tests of Co-integration Rank: Adjusted Belgian, French and Italian Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,149	34,89*	20,97	56,23*	29,68
1	2	0,091	20,77*	14,07	21,34*	15,41
2	1	0,003	0,57	3,76	0,57	3,76

* rejection at the 5% level.

Table 46 Tests of Co-integration Rank: Belgian (a), French (a) and Dutch (o) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,167	39,64*	20,97	50,30*	29,68
1	2	0,041	9,00	14,07	10,65	15,41
2	1	0,008	1,65	3,76	1,65	3,76

* rejection at the 5% level.

Table 47 Tests of Co-integration Rank: Adjusted Danish, French and Italian Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,175	41,80*	20,97	54,84*	29,68
1	2	0,057	12,72	14,07	13,04	15,41
2	1	0,001	0,32	3,76	0,32	3,76

* rejection at the 5% level.

Table 48 Tests of Co-integration Rank: Danish (a), French (a) and Dutch (o) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,120	48,31*	20,97	59,37*	29,68
1	2	0,046	10,15	14,07	11,06	15,41
2	1	0,004	0,91	3,76	0,91	3,76

* rejection at the 5% level.

Table 49 Tests of Co-integration Rank: Original German, Belgian, Danish, French and Dutch Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	5	0,243	33,45	33,46	75,48*	68,52
1	4	0,143	18,51	27,07	42,03	47,21
2	3	0,121	15,43	20,97	23,52	29,68
3	2	0,065	8,05	14,07	8,08	15,41
4	1	0,000	0,04	3,76	0,04	3,76

* rejection at the 5% level.

Table 50 Tests of Co-integration Rank: Original German, Belgian, Danish and French Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	4	0,242	33,25*	27,07	55,64*	47,21
1	3	0,109	13,78	20,97	22,39	29,68
2	2	0,069	8,57	14,07	8,61	15,41
3	1	0,000	0,04	3,76	0,04	3,76

* rejection at the 5% level.

Table 51 Tests of Co-integration Rank: Original German, Belgian, Danish and Dutch Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	4	0,171	22,49	27,07	47,56*	47,21
1	3	0,133	17,15	20,97	25,07	29,68
2	2	0,063	7,87	14,07	7,92	15,41
3	1	0,000	0,05	3,76	0,05	3,76

* rejection at the 5% level.

Table 52 Tests of Co-integration Rank: Original German, Belgian, and Danish Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,155	20,20	20,97	28,25	29,68
1	2	0,064	8,00	14,07	8,05	15,41
2	1	0,001	0,06	3,76	0,06	3,76

* rejection at the 5% level.

Table 53 Tests of Co-integration Rank: Original German, Finnish, Italian, Dutch and Spanish Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	5	0,280	39,40*	33,46	103,87*	68,52
1	4	0,255	35,38*	27,07	64,47*	47,21
2	3	0,162	21,16*	20,97	29,09	29,68
3	2	0,062	7,64	14,07	7,93	15,41
4	1	0,002	0,28	3,76	0,28	3,76

* rejection at the 5% level.

Table 54 Tests of Co-integration Rank: Original German, Finnish and Dutch Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	3	0,166	21,81*	20,97	40,75*	29,68
1	2	0,140	18,15*	14,07	18,94*	15,41
2	1	0,007	0,79	3,76	0,79	3,76

* rejection at the 5% level.

Table 55 Tests of Co-integration Rank: Original Belgian, Danish, Finnish, French, Italian, Dutch and Spanish Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	7	0,367	54,87*	45,28	175,26*	124,24
1	6	0,286	40,42*	39,37	120,39*	94,15
2	5	0,273	38,19*	33,46	79,97*	68,52
3	4	0,180	23,74	27,07	41,77	47,21
4	3	0,107	13,63	20,97	18,03	29,68
5	2	0,034	4,15	14,07	4,40	15,41
6	1	0,002	0,26	3,76	0,26	3,76

* rejection at the 5% level.

Table 56 Tests of Co-integration Rank: Original Belgian, Danish, French, Italian and Dutch Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0,95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0,95)$
0	5	0,276	38,76*	33,46	85,04*	68,52
1	4	0,214	28,87*	27,07	46,28	47,21
2	3	0,104	13,18	20,97	17,40	29,68
3	2	0,034	4,12	14,07	4,22	15,41
4	1	0,001	0,10	3,76	0,10	3,76

* rejection at the 5% level.

Table 57 Tests of Co-integration Rank: Original Belgian, Danish, French, Italian and Spanish Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0{,}95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0{,}95)$
0	5	0,345	50,82*	33,46	111,38*	68,52
1	4	0,235	32,13*	27,07	60,56*	47,21
2	3	0,143	18,52	20,97	28,43	29,68
3	2	0,079	9,89	14,07	9,91	15,41
4	1	0,000	0,03	3,76	0,03	3,76

* rejection at the 5% level.

Table 58 Tests of Co-integration Rank: Original Belgian, Danish, French and Italian Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0{,}95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0{,}95)$
0	4	0,234	31,96*	27,07	71,96*	47,21
1	3	0,216	29,25*	20,97	39,99*	29,68
2	2	0,085	10,61	14,07	10,74	15,41
3	1	0,001	0,13	3,76	0,13	3,76

* rejection at the 5% level.

Table 59 Tests of Co-integration Rank: Original Belgian, Danish, French and Dutch Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0{,}95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0{,}95)$
0	4	0,227	30,94*	27,07	51,06*	47,21
1	3	0,110	13,98	20,97	20,12	29,68
2	2	0,049	6,05	14,07	6,15	15,41
3	1	0,001	0,10	3,76	0,10	3,76

* rejection at the 5% level.

Table 60 Tests of Co-integration Rank: Original Belgian, Danish and French Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0{,}95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0{,}95)$
0	3	0,137	17,64	20,97	31,64*	29,68
1	2	0,109	13,85	14,07	14,00	15,41
2	1	0,001	0,15	3,76	0,15	3,76

* rejection at the 5% level.

Table 61 Tests of Co-integration Rank: Original Belgian, Danish and Italian Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0{,}95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0{,}95)$
0	3	0,225	30,65*	20,97	42,31*	29,68
1	2	0,091	11,50	14,07	11,66	15,41
2	1	0,001	0,16	3,76	0,16	3,76

* rejection at the 5% level.

Table 62 Tests of Co-integration Rank: Original Belgian, Danish and Dutch Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,176	23,19*	20,97	29,49	29,68
1	2	0,050	6,17	14,07	6,30	15,41
2	1	0,002	0,13	3,76	0,13	3,76

* rejection at the 5% level.

Table 63 Tests of Co-integration Rank: Original Belgian, French and Italian Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,190	25,26*	20,97	32,36*	29,68
1	2	0,056	6,97	14,07	7,10	15,41
2	1	0,001	0,12	3,76	0,12	3,76

* rejection at the 5% level.

Table 64 Tests of Co-integration Rank: Original Belgian, French and Dutch Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,106	13,50	20,97	19,73	29,68
1	2	0,050	6,12	14,07	6,23	15,41
2	1	0,001	0,11	3,76	0,11	3,76

* rejection at the 5% level.

Table 65 Tests of Co-integration Rank: Original Danish, French and Italian Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,219	29,62*	20,97	52,01*	29,68
1	2	0,167	21,92*	14,07	22,39*	15,41
2	1	0,004	0,47	3,76	0,47	3,76

* rejection at the 5% level.

Table 66 Tests of Co-integration Rank: Original Danish, French and Dutch Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,166	21,82*	20,97	28,77*	29,68
1	2	0,055	6,80	14,07	6,95	15,41
2	1	0,001	0,15	3,76	0,15	3,76

* rejection at the 5% level.

Table 67 Tests of Co-integration Rank: Original French, Italian and Spanish Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0{,}95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0{,}95)$
0	3	0,235	32,13*	20,97	47,81*	29,68
1	2	0,121	15,43*	14,07	15,68*	15,41
2	1	0,002	0,25	3,76	0,25	3,76

* rejection at the 5% level.

Table 68 Tests of Co-integration Rank: German (o), Belgian (a), Danish (a), French (a) and Dutch (o) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0{,}95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0{,}95)$
0	5	0,218	29,54	33,46	74,95*	68,52
1	4	0,148	19,28	27,07	45,41	47,21
2	3	0,132	16,94	20,97	26,13	29,68
3	2	0,073	9,07	14,07	9,18	15,41
4	1	0,001	0,12	3,76	0,12	3,76

* rejection at the 5% level.

Table 69 Tests of Co-integration Rank: German (o), Belgian (a), Danish (a) and French (a) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0{,}95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0{,}95)$
0	4	0,225	30,58*	27,07	55,88*	47,21
1	3	0,113	14,42	20,97	25,30	29,68
2	2	0,086	10,75	14,07	10,88	15,41
3	1	0,001	0,13	3,76	0,13	3,76

* rejection at the 5% level.

Table 70 Tests of Co-integration Rank: German (o), Belgian (a), Danish (a) and Dutch (o) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0{,}95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0{,}95)$
0	4	0,148	19,27	27,07	45,81	47,21
1	3	0,137	17,67	20,97	26,54	29,68
2	2	0,071	8,79	14,07	8,87	15,41
3	1	0,001	0,08	3,76	0,08	3,76

* rejection at the 5% level.

Table 71 Tests of Co-integration Rank: German (o), Belgian (a) and Danish (a) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	$-T\log(1-\lambda_{r+1})$	$\lambda_{max}(0{,}95)$	$-T\Sigma\log(1-\lambda_i)$	$\lambda_{trace}(0{,}95)$
0	3	0,125	16,04	20,97	27,48	29,68
1	2	0,090	11,34	14,07	11,44	15,41
2	1	0,001	0,10	3,76	0,10	3,76

* rejection at the 5% level.

Table 72 Tests of Co-integration Rank: Belgian (a), Danish (a), Finnish (o), French (a), Irish (a), Italian (a), Dutch (o) and Spanish (o) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	8	0,414	64,19*	51,42	205,30*	156,00
1	7	0,339	49,66*	45,28	141,11*	124,24
2	6	0,249	34,30	39,37	91,45	94,15
3	5	0,177	23,34	33,46	57,15	68,52
4	4	0,128	16,38	27,07	33,81	47,21
5	3	0,105	13,26	20,97	17,43	29,68
6	2	0,034	4,16	14,07	4,18	15,41
7	1	0,000	0,02	3,76	0,02	3,76

* rejection at the 5% level.

Table 73 Tests of Co-integration Rank: Belgian (a), Danish (a), Finnish (o), French (a), Italian (a), Dutch (o) and Spanish (o) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	7	0,306	43,88*	45,28	153,33*	124,24
1	6	0,295	41,99*	39,37	109,45*	94,15
2	5	0,235	32,09	33,46	67,46	68,52
3	4	0,130	16,74	27,07	35,36	47,21
4	3	0,110	14,05	20,97	18,62	29,68
5	2	0,035	4,27	14,07	4,57	15,41
6	1	0,003	0,30	3,76	0,30	3,76

* rejection at the 5% level.

Table 74 Tests of Co-integration Rank: Belgian (a), Danish (a), French (a), Italian (a) and Dutch (o) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	5	0,236	32,37	33,46	72,79*	68,52
1	4	0,174	23,01	27,07	40,42	47,21
2	3	0,096	12,12	20,97	17,41	29,68
3	2	0,042	5,15	14,07	5,29	15,41
4	1	0,001	0,14	3,76	0,14	3,76

* rejection at the 5% level.

Table 75 Tests of Co-integration Rank: Adjusted Belgian, Danish, French and Italian Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	4	0,233	31,90*	27,07	58,00*	47,21
1	3	0,140	18,12	20,97	26,09	29,68
2	2	0,063	7,85	14,07	7,97	15,41
3	1	0,001	0,12	3,76	0,12	3,76

* rejection at the 5% level.

Table 76 Tests of Co-integration Rank: Belgian (a), Danish (a), French (a) and Dutch (o) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	4	0,198	26,55	27,07	51,36*	47,21
1	3	0,126	16,11	20,97	24,81	29,68
2	2	0,068	8,48	14,07	8,70	15,41
3	1	0,002	0,22	3,76	0,22	3,76

* rejection at the 5% level.

Table 77 Tests of Co-integration Rank: Adjusted Belgian, Danish and French Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,177	23,36*	20,97	35,46*	29,68
1	2	0,094	11,85	14,07	12,11	15,41
2	1	0,002	0,26	3,76	0,26	3,76

* rejection at the 5% level.

Table 78 Tests of Co-integration Rank: Adjusted Belgian, Danish and Italian Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,140	18,07	20,97	25,84	29,68
1	2	0,062	7,66	14,07	7,77	15,41
2	1	0,001	0,11	3,76	0,11	3,76

* rejection at the 5% level.

Table 79 Tests of Co-integration Rank: Belgian (a) and Danish (a) and Dutch (o) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,134	17,23	20,97	26,58	29,68
1	2	0,073	9,14	14,07	9,35	15,41
2	1	0,001	0,22	3,76	0,22	3,76

* rejection at the 5% level.

Table 80 Tests of Co-integration Rank: Belgian (a), Danish (a), Irish (a), Italian (a) and Spanish (o) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	5	0,316	45,50*	33,46	79,92*	68,52
1	4	0,131	16,84	27,07	34,42	47,21
2	3	0,095	11,95	20,97	17,58	29,68
3	2	0,046	5,64	14,07	5,64	15,41
4	1	0,000	0,00	3,76	0,00	3,76

* rejection at the 5% level.

Table 81 Tests of Co-integration Rank: Adjusted Belgian, French and Italian Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,207	27,79*	20,97	35,68*	29,68
1	2	0,063	7,83	14,07	7,89	15,41
2	1	0,001	0,06	3,76	0,06	3,76

* rejection at the 5% level.

Table 82 Tests of Co-integration Rank: Belgian (a), French (a) and Dutch (o) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,126	16,11	20,97	23,92	29,68
1	2	0,062	7,67	14,07	7,81	15,41
2	1	0,001	0,15	3,76	0,15	3,76

* rejection at the 5% level.

Table 83 Tests of Co-integration Rank: Adjusted Danish, French and Italian Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,200	26,75*	20,97	41,95*	29,68
1	2	0,116	14,85*	14,07	15,20	15,41
2	1	0,003	0,34	3,76	0,34	3,76

* rejection at the 5% level.

Table 84 Tests of Co-integration Rank: Danish (a), French (a) and Dutch (o) Data, 4/1979 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,184	24,46*	20,97	33,65*	29,68
1	2	0,072	8,97	14,07	9,19	15,41
2	1	0,002	0,23	3,76	0,23	3,76

* rejection at the 5% level.

Table 85 Tests of Co-integration Rank: French (a), Italian (a) and Spanish (o) Data, 5/1987 - 6/1997

H_0:r	n-r	λ_i	-Tlog(1-λ_{r+1})	λ_{max}(0,95)	-TΣlog(1-λ_i)	λ_{trace}(0,95)
0	3	0,252	34,91*	20,97	51,00*	29,68
1	2	0,124	15,86*	14,07	16,08*	15,41
2	1	0,002	0,22	3,76	0,22	3,76

* rejection at the 5% level.